NIAB TAG

Agronomy Strategy 3

2019

Spring strategies

Nitrogen, sulphur, growth regulators, spring weed control in cereals and break crops

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Strategies 1:

Winter oilseed rape establishment, seed rates, seed treatments, sowing dates, weed control, disease control, autumn pest control.

Winter cereals: seed rates, sowing dates, seed treatments.

Stubble cultivations for grass weed control.

Strategies 2:

Winter cereals: autumn weed control, autumn pest control.

Winter beans: establishment, seed rates, weed control.

Strategies 3:

Nitrogen, sulphur, growth regulators, spring weed control in cereals and break crops.

Strategies 4:

Cereals and break crops: fungicide strategies.

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Agronomy Strategy 3 2019

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Introduction

This document contains our agronomy strategies for nitrogen, sulphur, growth regulation and spring weed control for spring 2019. The programmes outlined will be fine-tuned according to growing conditions as the season progresses, via field days and agronomy updates. Members can also discuss these strategies at any time with their regional agronomist.

We look forward to discussing and using these strategies during the coming season.

Regional Agronomy Team

1. Winter wheat

a) Nitrogen and sulphur

Total nitrogen dose

1. Feed wheat (first or second)

220-240 kg/ha N

This is appropriate for crops on long term arable land that is not regularly receiving organic amendments, and assumes yield potential of 9 t/ha – plus.

For lower yield potential total N around **200 kg/ha** would be appropriate.

2. Milling wheat (Group 1 and 2)

220-240 kg/ha N for yield, + an extra **40-80 kg/ha N** for grain protein

In these cases NMax values will govern total N dose but the higher yield potential of some of the current Group 1 and 2 varieties will allow total N at or close to these levels (see Table 1).

Sulphur

- All crops should receive **25-38 kg/ha SO_3** (10-15 kg/ha S) either with the first N dose or split between this and later doses, provided these are completed by GS32. Actual dose depends on soil type (lighter soils needing more) but also the N:S ratio (guideline 17:1 in grain) should not be allowed to get too high, i.e. for the higher N doses on milling wheats in particular, higher S doses should be considered.

Timing and splits

- First dose (late February/early March): apply 20-25% of the total, but slightly more, e.g. 25-30% of the total, on **second/third wheats** and give these priority for treatment when top-dressing starts.
- Further doses: apply the remainder in one or more applications between GS31 and 32.
- Where **urea** is used as the N source, the above totals are recommended though the first dose can be higher if desired, up to 50% of the total, and all N should be applied by mid-April. Avoid making applications during prolonged dry periods or prior to heavy rainfall.

Fertiliser type

- Nitrogen can be applied as urea, ammonium nitrate, calcium ammonium nitrate or a combination of these, though for milling wheats, or any where grain protein is important, AN should make up at least a major proportion of the later N applications, since urea is slightly less efficient than AN in terms of building grain protein.

- Analysis of the NIAB TAG database on wheat nitrogen has given us further confidence in our recommendations, particularly with respect to crop yield potential. That said, the range of appropriate total N doses is still quite narrow.
- Recent trials in the AHDB LearN project have shown that variation at field, farm and with season make precise calculations of the economic optima nearly impossible in advance. Errors are typically and commonly in the order of plus or minus 50 kg/ha N for feed wheat. However such errors have a very small effect on yield and margin. LearN has also compared approaches for calculating N requirements which showed RB209 was adequate if projected wheat yield was accounted for and the NIAB approach of standard N rate for first and second or continuous wheat on mineral soils of 220-240 kg/ha N was as accurate or better than using RB209.
- Low yield potential usually relates to low fertility so more nutrient needs to come from applied fertiliser. On the other hand, high yield potential usually comes from higher fertility and this will supply extra N to realise that potential, such that total applied N need not be significantly higher than for low yield potential crops.
- Our N response databases indicate that for every tonne of nitrogen-fertilised grain/ha, two-thirds of a tonne comes from the yield without nitrogen. These associations explain why the additional amount of nitrogen required for very high yields in field trials is less than would logically be expected.

Splitting

The number of splits is not critical. Splitting (rather than one dose) reduces the risk of losses through poor conditions at or following application. It is accepted that liquid fertilisers can be limited in the amount of N in each application so several splits are needed, though this is not essential for optimising fertiliser and crop performance.

First dose: in most seasons there is little benefit to splitting and, apart from second wheats and other situations mentioned below, some flexibility in timing. In dry seasons however the first dose (late Feb/ early March) can be an important means of getting nitrogen into the crop should a dry spring follow which would compromise uptake of later applications especially on lighter, drought prone land. It is a good insurance against such conditions and standard practice on many farms.

Subsequent doses: the remainder of the N, whether in a further one or more doses, should not be applied before GS31 as this may encourage stem extension, straw length and hence increase lodging risk. Aim to complete all N for yield by GS32.

- **Soil mineral nitrogen**: this has normally been ignored because potential yields tend to increase with more available soil nitrogen: therefore the crop can economically use it and this is a rather neat self-correcting system. It appears to explain why there is, on average, no real difference in the economic optimum nitrogen dose in field trials carried out in situations where soil mineral nitrogen is anywhere between 0 and 100 kg/ha N. In other words, potential yields tend to increase with increasing SMN but extra nitrogen may not be required for these higher yields, though using less applied N will reduce this yield potential.
- In some circumstances **soil nitrogen supply** may be a more relevant factor – this is often not very different to SMN but for some soils with high organic matter (5% +) this does make a nitrogen contribution hence total supply is higher than just available mineral N. Factors contributing to this such as regular manure use or recent grass in the rotation often improve yield as soil structure, available water and rooting are usually better. This again would give higher SNS, therefore higher yield potential without applied N and may lead to a reduced demand for applied N.
- RB209 quotes a relationship of 0.5 t/ha for every 10 kg/ha applied N, which ties in well with our recommendations. Most growers will budget for, or at least aspire to, 10 t/ha wheat yield.
- **Post-harvest grain N analysis** may give a retrospective guide to whether the crop received enough N but only where the values are extreme, since the guideline for grain N content increases with increasing N optima. Hence for feed wheat, if 200 kg/ha N was optimum the grain N should be around 1.95-2.00% N, but if optimum is around 300 kg/ha the grain N should be 2.1-2.15%. Hence, there is difficulty applying this guideline because the true optimum is not known in advance.
- As well as second wheats, wheat following **oats** may need a prompt start to the spring top dressing. Oats (also linseed and spring oilseed rape) do not leave as much residual N as other break crops, and as they are often under-fertilised to reduce lodging risk, may scavenge more soil N leaving less for the next crop.

Milling wheats, i.e. where yield and protein content are targets

- In these crops it is important to take expected yield into account, apply sufficient N for this and add further N for protein enhancement. Where yield potential is high and soil N levels not excessive, and no specific late season N, e.g. foliar applied urea is used, then
    - up to **320 kg/ha** of soil-applied N may need to be applied to achieve the 13% protein content specified in most bread making contracts, particularly with modern high yielding varieties.
    - Up to **280 kg/ha** of N may need to be applied when expected yields are at the 9-10 t/ha level and no foliar urea is to be used.
    - Up to **240 kg/ha** of N may be required when the expected yields are around the 8 t/ha level.

    (In NVZs however there is a requirement to ensure NMax limits are not exceeded).

Form of N fertiliser

- For applications up to GS32 (i.e. for yield), NIAB TAG trials have found no significant difference between solid and liquid N forms, or between AN and urea, even in dry springs. Hence, **no adjustment in total dose of urea is necessary** to compensate for theoretical losses. Whether using urea or ammonium nitrate (or UAN) total N recommendations given above will be adequate for yield if applications are well-timed.
- Late spring applications and/or dry soils can lead to inefficiencies in urea performance. Timing of application on light soils, particularly in late March/early April, should be governed by weather conditions more than crop growth stage, for example aiming to apply urea just ahead of rainfall (enough to dissolve the prills and wash them in, typically 3 mm minimum). Application timing is more flexible, which helps in this respect, for example it can be applied earlier than for AN due to the slower availability of N. Later applications, e.g. late April onwards, may be less effective than equivalent AN treatments, and urea applied in dry weather to light calcareous soils can suffer N losses through volatilisation. On heavier soils, even in dry weather, potential losses are much smaller and generally there is no difference between these forms of nitrogen for any timing regime.

Foliar urea spray v soil applied N for protein

- Foliar urea (sprayed on the ear) is the most reliable way of putting N into the grain to build protein. Soil-applied N (AN rather than urea) as a specific late dose around GS37-39 can be as effective provided: a) there is sufficient rainfall soon after application to allow take-up by the crop, and b) previous N doses have fulfilled the yield requirements of the crop: otherwise such a nitrogen treatment could be used by the crop to build more yield, diverting it from grain protein production and possibly causing a yield dilution effect on this.

Nitrogen management of late sown wheat

- Crops sown late (e.g. November), with grass-weed management in mind, are often slow to establish. It is important to make sure these crops reach their maximum potential and are as competitive as possible with grass-weeds throughout spring. A wheat plant's first response to lack of N is to lose tillers; these later sown crops can ill-afford this and earlier NIAB TAG work showed that the only input to increase final tiller populations in later sown crops was an early start to spring nitrogen treatment, preferably splitting the first dose, say 20 kg/ha in early February and 20 kg/ha in late February. This spoon-feeding of N is likely to be impractical so at least ensure that the later sown crops are the first treated when top-dressing starts in spring.
- **Spatial variation in N dose**: where N is applied variably to the field according to crop structure or yield potential, the basic dose on which the variation is based should be as discussed above.
- **Sulphur**: NIAB TAG trials have recorded consistent responses to sulphur applications on light soils, and on medium soils where no organic manures or other soil amendments have been applied. Although responses have been variable on heavier soils, the yield penalties associated with sulphur deficiency mean that application of sulphur fertiliser should be routine on all soil types unless sufficient has been supplied by other means (manures, composts etc).

Table 1. Nmax table for winter wheat (total N in kg N /ha)

Predicted yield (t/ha)	8	9	10	11	12
Feed	220	240	260	280	300
Feed on shallow soils	240	260	280	300	320
Milling	260	280	300	320	340
Milling on shallow soils	280	300	320	340	360
Adjustment for yield is 20 kg/ha N for every t/ha over 8 t/ha					
Adjustment for shallow soil is an additional 20 kg/ha N					
Adjustment for milling wheat is an additional 40 kg/ha N					

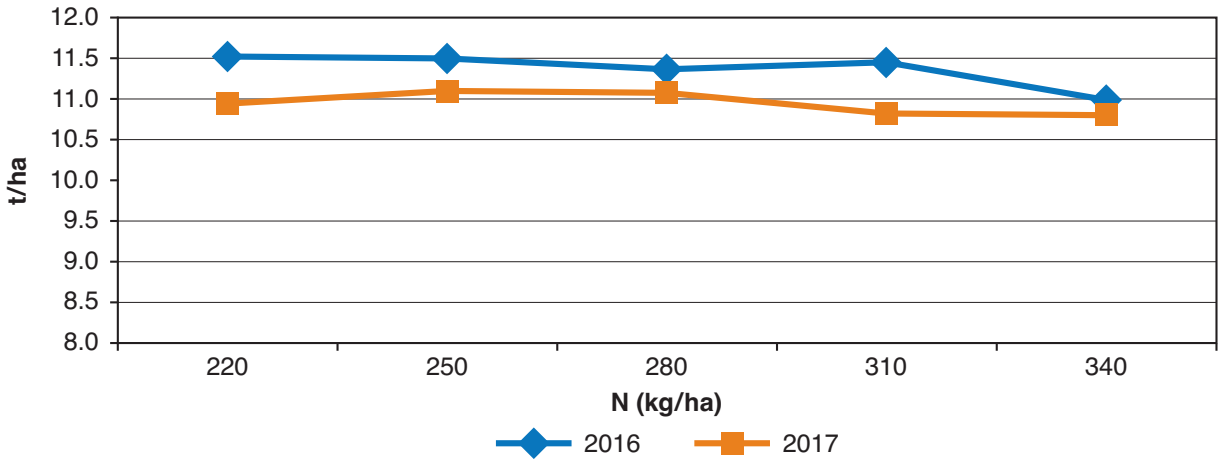
These adjustments should allow for most eventualities.

You may need to be able to justify your yield prediction.

NIAB TAG recommendations for total N have been consistent for many years. With more growers achieving 10 t/ha-plus of wheat the question inevitably arises whether crops have higher N demands now. Two years of trials at the Warwick Centre looked at incremental N doses above the farm standard of 220 kg/ha, up to a total of 340 kg/ha. In 2016 KWS Santiago was used, in 2017 the trial was on KWS Siskin.

In both years there was no response to increased N above the farm standard (Figure 1).

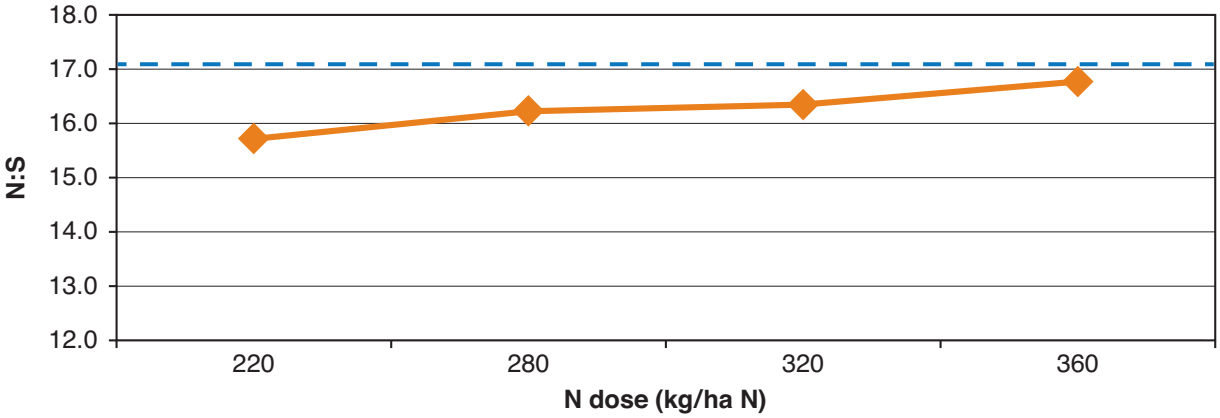
Figure 1. Nitrogen response in wheat, Warwick 2016 and 2017



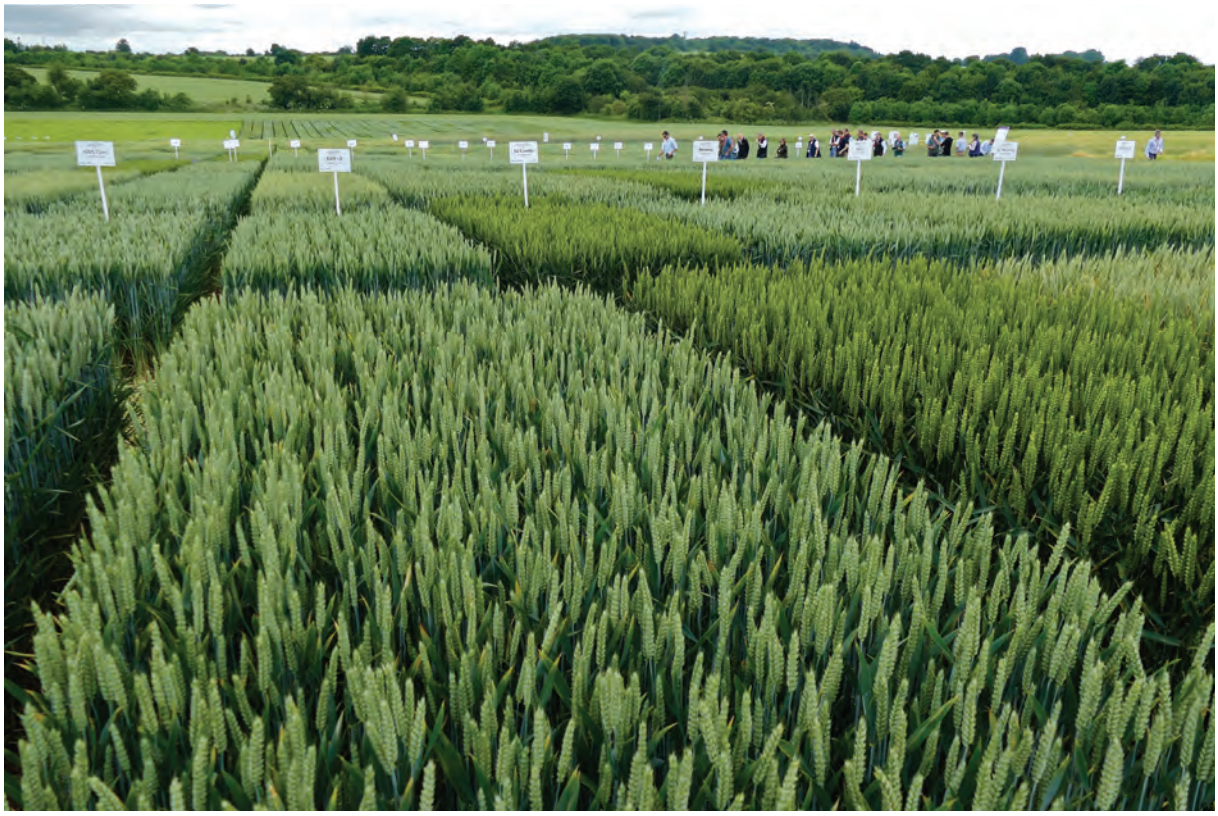
Available soil N (early March) 2016: 13 kg/ha. 2017: 18 kg/ha

In 2016 specific weight was also reduced when N was increased above the baseline amount. This effect was less marked in 2017.

Figure 2. Effect of nitrogen dose on grain N:S ratio. Cv Skyfall, Cirencester 2018



With the high N doses common on milling wheat, Figure 2 shows how N:S can increase (i.e. S become deficient). In this trial none of the N doses produced a deficiency (guideline 17:1: all treatments received 45 kg/ha SO_3) but the figures show that this is possible and sulphur dose should be considered alongside N dose in such situations.



b) Growth regulation

Growth regulator programmes

(i) Most crops

Chlormequat 1.5-2.0 l/ha (1,200-1,500 g a.i./ha) **at GS30-31**

Chlormequat is a standard input for most wheat crops. Even stiff varieties at little risk of lodging can benefit from this low cost treatment but dose should be kept low in such situations.

(ii) Low-moderate lodging risk

Split chlormequat: e.g. 1.5 l/ha GS30 followed by **0.5 l/ha GS31**

Splitting the chlormequat gives better straw shortening than a single dose and would also give some insurance against poor weather conditions at either application. It is also useful insurance where subsequent T2 application (e.g. Terpal) has to be reconsidered due to weather stresses.

(iii) Moderate-high lodging risk – two-spray programme

Early treatments as above, followed by

Terpal 0.75-1.0 l/ha GS33-37 or **Canopy 0.75 l/ha** GS37-39

The T2 treatment, involving ethephon-based products in sequence with chlormequat, should only be applied where soil type, variety and/or previous experience suggest a tangible lodging threat, such that a higher input than chlormequat (± Moddus or Canopy) alone is required.

As above, the effectiveness of this sequence can be further improved by splitting the chlormequat.

Reduced doses, or omitting the treatment altogether, may be necessary where warm/dry weather prevails at this timing. Higher earlier input as described above (splitting chlormequat) can help in this respect.

(iv) Early sown or otherwise thick, forward crops

Chlormequat 1.5 l/ha + either **trinexapac 25-50g a.i./ha** (e.g. Moddus 0.1-0.2 l/ha) or **Canopy 0.5 l/ha** at GS30-31

This approach will give greater strengthening of lower internodes which are in danger of excessive elongation in dense crops, as might be produced by early September sowing, and should only be considered for this category of increased lodging risk.

Where chlormequat is planned to be split, trinexapac or Canopy treatments can also be split and applied with each chlormequat application.

If also considering Canopy for later (T2) application, there are no restrictions on the number of applications providing the total dose applied does not exceed 1.5 l/ha.

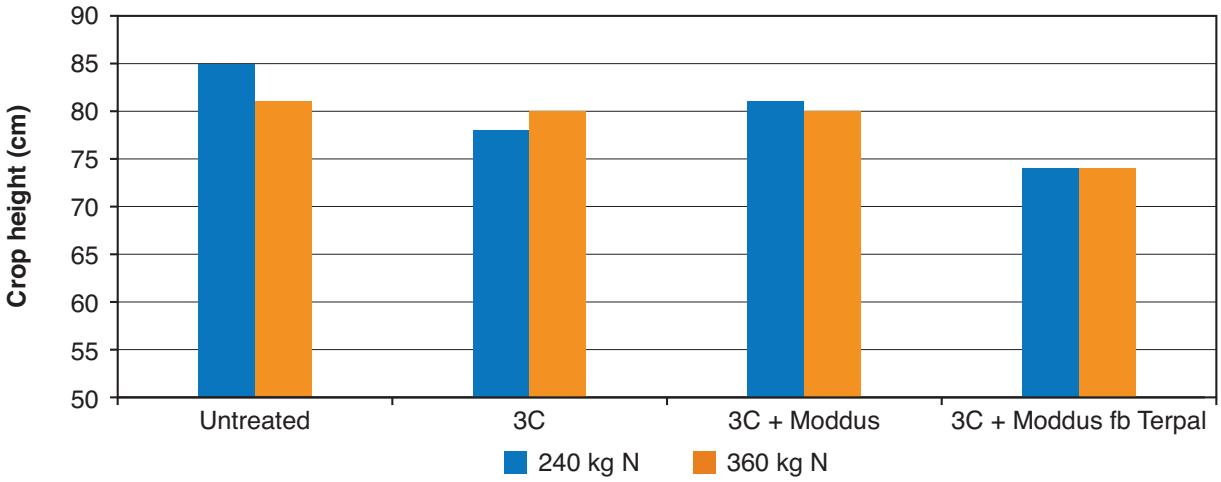
Medax Max is an alternative to Canopy. Containing prohexadione and trinexapac-ethyl, it is 'quatless' should this be of value, and like Canopy (and Moddus) can be used alone or mixed with chlormequat. It can be used up to and including the end of booting. Experience suggests that 0.2 kg/ha is equivalent to 0.5 l/ha of Canopy.

Assessment of lodging risk and choice of input level

Growing conditions throughout the season are the main influence on lodging risk so the exact risk cannot be known until the end of the season. Hence much of the growth regulator programme is precautionary but soil fertility, varietal straw strength, field altitude and aspect and, of course, past experience can all be considered when putting a programme together.

Although chlormequat can increase yield in the absence of lodging, where grain site retention in particular is important, higher PGR input can reduce yield if it is not required for lodging control. Our Strategy above mentions Moddus or Canopy added to chlormequat where crops are particularly thick at the relevant growth stages. However in other situations (light soils for example) they will have little or no benefit. In a trial at Cirencester in 2017, October sown on light stony brash, adding Moddus to chlormequat gave no additional crop shortening:

Figure 3. Effect of PGR programme on crop height. Cirencester 2017



LSD 5.9 cm

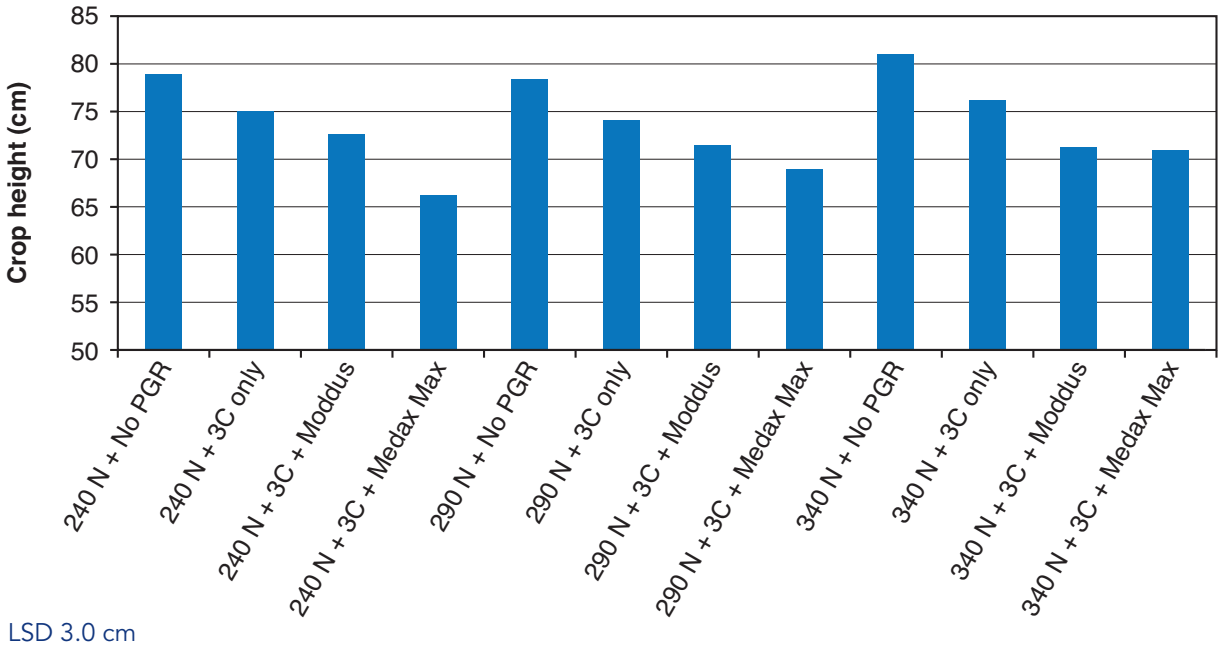
WW17-9147. Cv Skyfall. 3C chlormequat 1.5 l/ha, Moddus 0.2 l/ha, Terpal 1.0 l/ha

A range of N doses were included, figures are given for the highest and lowest (240 and 360 kg/ha N).

No lodging occurred in the trial. With 240 kg/ha N, chlormequat alone reduced crop height by 8 cm, Moddus gave no further shortening whilst the three-way sequence with Terpal gave a further 6 cm shortening. Where total N was 360 kg/ha only the highest PGR input reduced crop height. The same trial in 2018, under drier conditions, produced a much shorter crop overall with no significant crop-shortening from any PGR treatment irrespective of N dose (an example of seasonal conditions having a considerable influence on lodging risk).

On slightly heavier soil (sandy loam) in Kent, a similar trial (also Skyfall) showed a more regular progressive crop shortening from increased PGR input (Figure 4). Again, no lodging occurred.

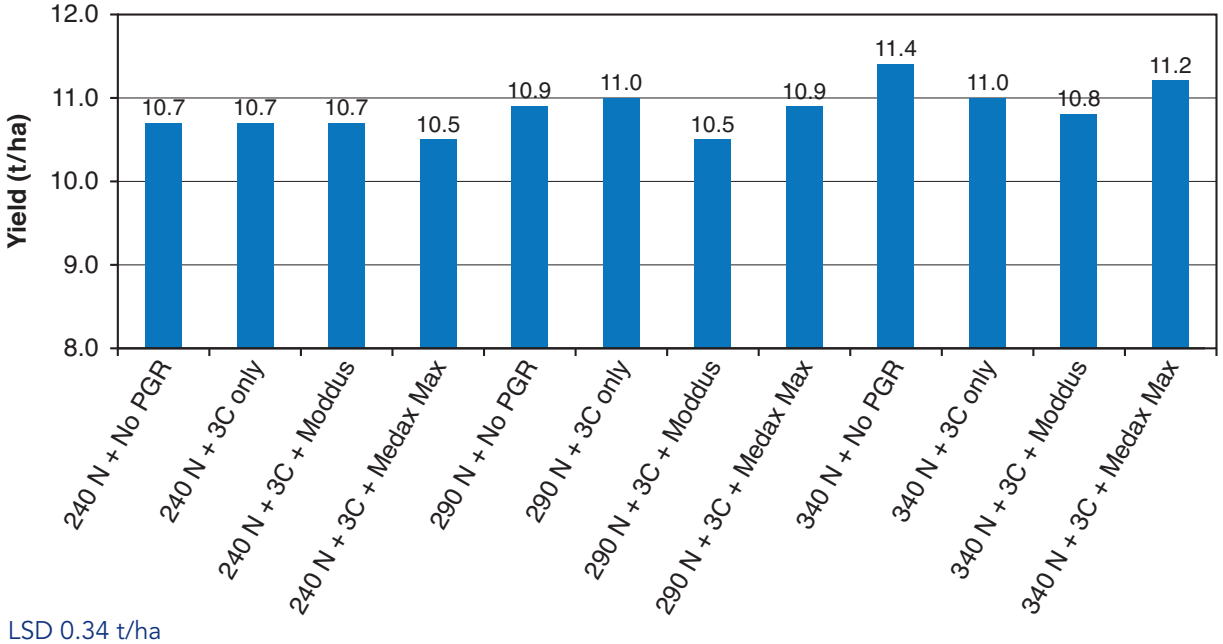
Figure 4. Nitrogen and PGR effects on crop height, East Malling 2017



LSD 3.0 cm

3C chlormequat 1.25 l/ha, Moddus 0.1 l/ha, Medax Max 0.2 kg/ha. All PGR treatments applied at GS31.

Figure 5. Nitrogen and PGR effects on yield, East Malling 2017



LSD 0.34 t/ha

With the lowest N dose the PGR treatment had no effect on yield (Figure 5). Higher N doses tended to give slightly higher yields but PGR treatment often confounded this, significantly reducing yield in some cases. The use of more robust PGR treatments should be avoided unless absolutely necessary due to higher lodging risk.

c) Spring weed control

Grass-weed control

1. Black-grass

Spring treatment will mainly be governed by whether or not it is the first treatment. Other factors include weed numbers and size, crop population and vigour/size, and resistance status (known or suspected) of the black-grass. Irrespective of the autumn control measures, fields with grass-weed problems should be assessed carefully in early spring to determine what, if any, further action is needed.

(i) No autumn treatment applied

Options will depend on the size of the weeds. If these are established with two leaves or more then the course of action should be based on contact-acting products as in (ii) below. If the crop was sown late and grass-weeds are still emerging then residual products are still an option. Quirinus (flufenacet + picolinafen) is an option up to before the end of tillering (GS30). Pontos, Liberator and, Defy can also be used at this time, but only at reduced rates. Latest timings are before GS30 for Pontos, before GS23 for Liberator and to GS21 for Defy.

(ii) Further treatment needed (assuming no post-emergence treatment applied to date)

Consider Atlantis or Monolith as below (resistance to ALS-inhibitor chemistry is common in black-grass so this assumes knowledge of resistance status suggests that they will be effective).

- **Atlantis OD, Horus/Hatra 1.2 l/ha**

  + Biopower + a partner product with a different mode of action: (for use of either product in the spring, Bayer CropScience suggest no partner product but will support a tank mix with Liberator or similar products as mentioned in c) below).

- **Monolith 0.33 kg/ha**

  Do not mix partner products with Monolith. Avoid using Monolith when crop growth has resumed as some damage is possible.

Partner products

a) **Defy** 2.0-3.0 l/ha

b) **Pendimethalin** (Anthem, Stomp Aqua, etc) at 900-1000g a.i./ha.

c) **Liberator** (0.3 l/ha) (Regatta/Herold) up to 'before crop GS24', before 31 March – where any autumn application of flufenacet was made before crop GS13 (up to a maximum **240 g a.i./ha**) and autumn application of diflufenican has not exceeded **90 g a.i./ha**.

No further treatment needed?

Assess the post-winter population carefully. We suggest any black-grass population above 1 plant/m^2 in winter wheat should be considered for further treatment. Slightly higher populations can be tolerated if the crop competition, from a strong uniform plant population (>200 plants/m^2), is good and the target weeds are already suffering from this competition as well as from earlier herbicide treatment. Early nitrogen, to encourage the crop's competitive advantage, should also be a priority.

Further treatment is needed – but post-emergence treatment of Atlantis, Broadway Sunrise or Unite has been previously applied.

There are no selective herbicide options that offer consistent effective control. Patch spraying with glyphosate may be an option. Populations above 30 plants/m^2 in later winter or early spring would suggest an unsustainable level which it may be best to spray off and re-drill with a spring crop or fallow.

- Ideally black-grass programmes should be completed in autumn though this is not always possible. Increasingly good control relies on crop competition as well as chemical control and more than once in recent seasons a cold spring has suppressed tillering in the wheat crop, resulting in poor competition with weeds and a perceived poor performance from the herbicide programme. This would have more significance for programmes involving spring treatments, making these generally more variable in performance.
- Where crops are less competitive with surviving weeds, if further herbicide treatment is planned, aim to apply before applying nitrogen (if conditions allow) in order to keep the target plants as weak as possible. (Recent work at the NIAB TAG Black-grass Centre in Cambridgeshire looked at seedbed (autumn) nitrogen aimed at boosting early growth in the crop hence making it more competitive. In the event the nitrogen stimulated the black-grass more than the wheat making the situation worse – see *Members Trial Results*, p.208).
- Where a significant amount of the surviving population is more confined to severely infested patches, marking these and removing them with glyphosate may well be a better option than any further overall selective herbicide use.
- Check that grass-weeds are actively growing, not suffering from stress (including dry conditions) and that the herbicide will dry on the leaves during the day.
- Check product tank mixes with Atlantis (other than with Biopower) in spring for efficacy and crop safety. After mid-March, use 0.4-0.5 kg/ha Pacifica (or Pacifica Plus) + Biopower; NIAB TAG data suggest that this is too late to get good activity from Atlantis mixes.

Care needs to be taken when tank-mixing Atlantis and similar products, particularly with fungicide and growth regulators, as these may compromise control.

It is particularly important to apply Atlantis or Pacifica in optimum conditions in order to achieve the highest level of control possible, e.g.

(i) sufficient soil temperature for weed growth

(ii) leaves dry, or likely to dry before nightfall.

It may take time to achieve these conditions. By mid-March, the days are becoming longer and typically growth can be observed. Periods of suitable conditions can occur earlier but are often short-lived and control can be disappointing.

Experience suggests that where growth can be observed in early to mid-March and is expected to continue then Atlantis will provide good control despite the fact that soil temperatures may not be consistently over 6°C. Dry soils, which can occur after this period, will compromise control.

Other grass-weeds

2. Rye-grass

Atlantis as above, **Pacifica**, **Broadway Star** (0.265 kg/ha) – all with recommended adjuvants; check crop and soil conditions are good before applying these – or Axial Pro (0.55-0.82 l/ha according to weed size). Again, resistance levels may compromise the performance of these.

Also, since rye-grass will tend to germinate throughout the year, adding in a residual component will help reduce competition from spring germinating plants, for example pendimethalin, flufenacet, or Tower 2.0 l/ha (delivering 500 g/ha chlorotoluron, 80 g/ha diflufenican, 600 g/ha pendimethalin).

(NIAB TAG 2018/19 trials will help us to fine-tune this advice with resistant rye-grass in particular).

3. Bromes

(i) Broadway Star (0.265 kg/ha)

or

ii) Monolith (0.33 kg/ha)

Alternatively **Atlantis (0.4 kg/ha)** + **Hurricane (0.2 l/ha**, or 0.1 l/ha if Liberator used in autumn)

(iii) Attribut (100 g/ha) or **Pacifica/Pacifica Plus (0.5 kg/ha)** can be used.

Check labels regarding recommended adjuvant use;

e.g. Abacus, Drill, Tonto, Roller, Respond, Intracrop Warrior with Broadway Star;
Oil, Arma, Toil, Actipron with Attribut.

- Broadway Star may provide better control of sterile brome than Atlantis. Apply to actively growing bromes, preferably by mid-March.
- Note also that spring applications of an ALS-inhibitor product may only stunt sterile brome, rather than kill it completely.

4. Wild-oats only: Axial Pro (pinoxaden) at 0.4-0.82 l/ha, clodinafop-propargyl (e.g. **Topik**) or **Foxtrot/Oskar/Polecat** (fenoxaprop-P-ethyl) are the most effective options. **Broadway Star** also has good activity against wild-oats. Treat when the wild-oats are accessible to the spray, i.e. not when the crop is in stem extension and shielding them. Check labels for adjuvant use.

Note there are fop-resistant wild-oat populations so, if possible, check resistance status before treating (note however Broadway Star has good activity against ACC-ase resistant populations). Latest crop timing for Broadway Star is end of GS32, GS41 for Axial Pro and Topik and GS39 for Polecat/Oskar/Foxtrot.

5. Annual Meadow-grass: In situations where meadow-grass is the main grass-weed and it has not been controlled in the autumn, **Othello** is the strongest option but, as with all meadow-grass control, it will work better if applied before the weeds start to tiller. The three-tiller stage (GS23) of the weed is the latest that Othello can be expected to give control (max rate 1.0 l/ha).

6. If **rough-stalked meadow-grass** rather than annual meadow-grass in the main problem, **Axial Pro**, **Topik**, **Polecat, Oskar** or **Foxtrot** should give good post-emergence control up the late tillering stage, as will **Atlantis**. **Othello** will give control until the early tillering stage.

Additional notes for grass-weed herbicide use

- ACC-ase inhibitors such as Topik, Axial Pro etc: remember that a particular fop/dim/den can only be used once in a crop. Only use a second ACC-ase inhibitor to control different weeds at a different timing.
- Season total dose for diflufenican is 125 g/ha, so this needs to be watched where more than one product containing this active is being used.
- Season total dose for pendimethalin is 2,000 g/ha, where multiple products containing this active are used some care is needed. As spring progresses pendimethalin will become less effective, and other options should be considered for late March onwards.
- Where an ALS-inhibitor herbicide is used for grass-weed control, usually any second ALS-inhibitor herbicide applied must not be a product that claims grass-weed control.
- Consider spray water hardness, this can affect the efficacy of grass-weed ALS-inhibitor products and NIAB TAG can test this for you.

Broad-leaved weed control

Treatments following earlier herbicide applications: grass-weed programmes often cater for broad-leaved weeds also, except for treatment of cleavers and any spring germinators.

Compliance with the number of **ALS-inhibitor herbicides** that can be applied is usually the first consideration where additional broad-leaved weed control is needed following previous autumn herbicides. As a general rule, only two ALS-inhibitor products can be applied to a crop, with only one having grass-weed activity. There are some specific exceptions to this, and for broad-leaved weed control the main one is: products containing florasulam can be applied once in the autumn and again after 1 February provided the maximum total dose of 7.5 g a.i./ha is not exceeded.

Where resistance in broad-leaved weeds is known or suspected then mixing actives is very important.

Products

1. Cleavers

- Where no previous herbicide has affected their growth, healthy cleavers at low – moderate populations (3-10/m^2) should be treated by crop GS32. Lower cleaver populations, or where their growth has been severely affected by previous herbicides, can be left until crop GS37-39.
- Arylex products (Zypar and Pixxaro EC) are particularly effective (see *Zypar New Product Guide*, March 2017). Otherwise, products containing **both** fluroxypyr and florasulam tend to be more reliable in early spring than either/or amidosulfuron (e.g. Eagle) alone. **Broadway Star** also offers reliable activity on cleavers at this time. (Pixxaro EC and carfentrazone-ethyl products are mentioned in the non-ALS options section on page 16).
- Be aware that there are large variations in the fluroxypyr:florasulam ratio in different products. Spitfire has the closest pre-formulated ratio and should therefore be more reliable at this timing than products such as Starane Gold or Starane XL, where the florasulam is contributing much less than the fluroxypyr as a partner herbicide.
- From mid-April or so, assuming better growing conditions, fluroxypyr, either alone or with florasulam or Arylex, can be used. If used straight, the rate of fluroxypyr should not be less than 150 g/ha. Note that authorisation for some fluroxypyr products ended during 2017 (e.g. Starane 2), but other straight fluroxypyr products are available (e.g. Hurler, Crescent). **Starane Hi-Load** will be the main option for straight fluroxypyr from Corteva Agriscience. At 0.45 l/ha, this offers similar weed control to 0.75 l/ha Starane 2.

2. Other broad-leaved weeds

- Programmes based on the ALS-inhibitors offer inexpensive but effective control of most broad-leaved weed problems. However, total reliance on this mode of action can lead to target-site resistance, now recorded in common poppy, common chickweed and scentless mayweed. Hence, ensure over the rotation and/or in the autumn of the winter cereal that these species are controlled with herbicides with a different mode of action.
- **Metsulfuron-methyl** is still the most useful ALS-inhibitor herbicide. Less than full dose, when used alone or in a product mix, is required for many species when they are small and actively growing. Also useful, at robust doses, for sugar beet volunteers and late spring control of docks and thistles. Can be used after 1 February and the 3-leaf stage of the crop. Its weed control spectrum can be improved by mixing with CMPP, fluroxypyr or bromoxynil, particularly where polygonums, speedwells or cleavers are targeted. However these additions do restrict the treatment timing.
- **Zypar**, based on Arylex chemistry will also control a wide range of broad-leaved weeds. Control from Zypar includes some traditionally more difficult weeds, including crane's bill, fat hen, poppy, wild carrot, fumitory and cleavers. It shows a high degree of crop safety and is less sensitive to weather conditions than many other products, allowing earlier application when weeds are still small. Other florasulam-based products (e.g. **Spitfire**) also give effective control of a wide range of broad-leaved weeds.
- Straight florasulam (e.g. **Lector**). **Lector** can be used up to GS39 in winter wheat and winter barley. Maximum dose is 0.15 l/ha (of which up to 0.075 l/ha can be applied in the autumn). **Lector Delta** is also available (50 g/l florasulam + 500 g/l DFF), latest use is end of GS32.

Non ALS-inhibitor options

There is a good range of non-ALS herbicides still to choose from to provide broad-leaved weed control in the spring, though they often have to be used in tank mixes to get effective broad-spectrum control.

- **Pixxaro EC** – based on the active Arylex combined with fluroxypyr this has restricted availability but provides an option with good activity on a wide range of weeds.
- Products with a mix of hormone type herbicides such as dicamba + CMPP-p (e.g. **Foundation**) can be used from the 5-leaf stage to before GS31 of the crop and will control a range of broad-leaved weeds including small/smallish mayweeds. Products containing 2,4D or MCPA are restricted to applications between GS30 and before GS31 and will not be so good on mayweed or chickweed.
- **Straight CMPP-p** products (e.g. **Optica**) can be used from 1 March to before GS33.
- **Straight MCPA** product labels vary more, **Easel** can be used up to GS39 in winter wheat, **Agritox** can be used from 1 March to before GS31. In good conditions, MCPA will provide control of poppies.
- **Straight bromoxynil** products, e.g. **Maya**, **Buctril** have now replaced products based on ioxynil + bromoxynil. Latest timings vary a bit between products, but Maya can be used to the end of GS31 and Buctril to the end of tillering (GS29).
- **Cyclops** (26.7g/l diflufenican + 160g/l bromoxynil) can be used in winter wheat and winter barley at 1.25 l/ha before the end of February, or up to 1.9 l/ha from 1 March, but before GS32.
- Straight carfentrazone-ethyl (e.g. **Aurora 40 WG**) can also be used anytime up to before GS33, whilst carfentrazone + CMPP-p (**Platform S**) cannot be used before 1 March. Carfentrazone-ethyl provides useful control of speedwells and cleavers in particular.
- Clopyralid (e.g. **Dow Shield 400**) can also be used from 1 March up to before GS33 to help with control of small mayweeds and to assist the activity on some other weeds. However, note that care is needed regarding use of straw and residues, and it should not be used where the following crop is winter beans or where legume-containing cover crops form a significant element of the farm's rotation.

2. Winter barley

a) Nitrogen and sulphur

Total nitrogen dose

1. Feed barley (conventional and hybrid)

140-180 kg/ha N

Total dose will be influenced by yield potential and lodging risk.

For estimated yields around 8 t/ha, most crops will require 150-180 kg/ha.

- Where potential yields are higher than this around 20 kg/ha N extra for each t/ha expected yield above 8 t/ha is justified. Some growers in such situations apply up to 220 kg/ha N but we only have data for doses up to 200 kg/ha N.
- In exceptional circumstances where yield expectation is much lower (lighter, drought-prone soils) there may be little response to doses above 125 kg/ha. As for winter wheat, RB209 suggests 0.5 t/ha extra yield from each 10 kg/ha applied N, in this case up to a maximum target yield of 11 t/ha.

Residual soil fertility will only influence optimum dose if available soil N reserves (SMN) are over 100 kg/ha N.

2. Malting barley

Apply between **100-150 kg/ha** N to achieve 1.55-1.85% grain N. Apply less if the target grain N is lower.

This is a broad range but previous experience of grain N related to applied N will give useful guidance on the total N required.

Although difficult to predict, low yields and/or early maturity (e.g. in dry seasons) are likely to concentrate grain N so the lower end of this range is more appropriate.

Sulphur

Unless sulphur-containing manures etc have been applied, apply **25-38 kg/ha SO_3** (10-15kg/ha S) with the first N dose, irrespective of soil type. As with winter wheat the exact dose can be related to the planned N total.

Timing

For both feed and malting crops, apply the nitrogen in two doses (three splits may be more convenient for higher total doses):

First dose: 40-50 kg/ha N late February to early March, treat before winter wheat. This dose takes on greater significance in a dry spring, and well-tillered crops in particular should take priority as these are likely to run out of soil N (and hence start to lose tillers) before smaller crops, and before wheat crops.

Second dose: the remainder of the total N around GS30-31; applications prior to GS30-31 will encourage straw growth and hence lodging, but may be necessary for malting crops to achieve the desired grain N.

Hyvido barley

These crops can benefit from small variations in the timings and splitting of the nitrogen (e.g. 30% at GS25, 50% at GS31 and the remaining 20% between GS32-37). NIAB TAG results to date have shown a slight benefit to this system in the hybrids specifically.

Feed barley

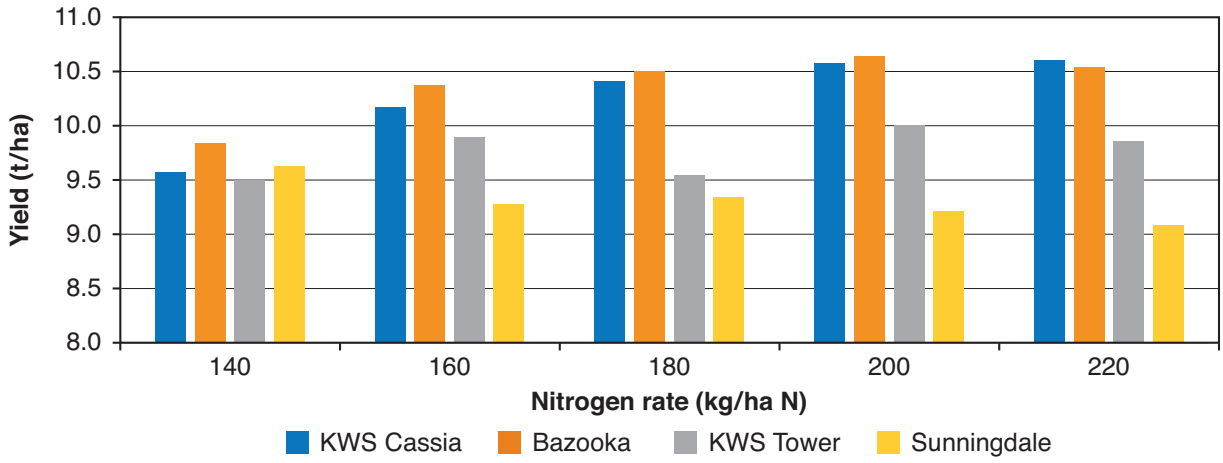
- As with wheat (qv) **urea** would be as effective as **ammonium nitrate** for delivering optimum yield.
- Later-timed final doses than those mentioned previously can have yield benefits but are likely to be compromised by drying soils and are hence particularly risky.

Malting barley

- The winter crop can be a very difficult crop to grow to consistent malting quality standards. Regardless of farmer inputs the weather plays a big part in achieving target grain N in winter barley.
- In drier seasons, on lighter soils particularly where yield potential is low, N doses of 100-125 kg/ha N are often appropriate whereas with higher yields doses of 150 kg/ha can still give low grain N.
- The lower N doses suggested for feed crops (above) make it easier to grow malting varieties at this feed level of N and then assess the suitability for malt of the grain N at the end of the season.

In 2018 a trial was conducted at Morley and at Croft, looking at nitrogen dose and growth regulator interaction on a total of four varieties. Yields are shown in Figure 6.

Figure 6. Effect of increasing N dose on yield. Morley (Norfolk, cv Cassia and Bazooka) and Croft (N.Yorks, Tower and Sunningdale) 2018



At Morley both varieties (KWS Cassia and Bazooka) showed increased yield response to nitrogen dose but the response was fairly level after 160 kg/ha. On the heavier, but lower yielding, site at Croft there was no response above the lowest N dose of 140 kg/ha, reflecting the influence of yield potential on optimum N dose.

b) Growth regulation

For most crops a two-spray programme is advisable

T1 (GS30)

a) 1.25-2.0 l/ha chlormequat (900-1,500 g a.i./ha approx.)

This will be needed by most crops unless particularly low yield potential and/or very stiff strawed. It will strengthen lower internodes, encourage tiller retention but must be followed by a second PGR as described below.

For thick/forward crops of weak-strawed feed varieties, and for **hybrid barleys** the first part of the sequence should be strengthened by adding trinexapac-ethyl (e.g.Moddus/Optimus etc) or Canopy to the chlormequat at GS30-31.

Either

b) 1.25 l/ha chlormequat + 25 (-50) g/ha trinexapac-ethyl

(e.g.Moddus 0.1 (-0.2 l/ha), Optimus 0.15 (-0.3 l/ha) **at GS30-31**

or

c) 1.25 l/ha chlormequat + Canopy 0.5-0.75 l/ha

T2 (GS33-49)

Ethephon-based product, e.g. 0.5-1.0 l/ha Terpal (+ wetter) or **0.3-0.6 l/ha Cerone**

In winter barley, the 'T2' timing (GS32-39) is the most effective at lodging control. However it is approved up to GS49. Where a T1 is not applied, it allows an assessment of straw growth before a decision on dose needs to be made. If applications are late (approaching GS49) then a higher rate may be appropriate.

However, where a T1 treatment was applied, then a T2 treatment is a necessary part of the programme.

- Following adverse effects in trials, chlormequat plus Moddus is not generally advised on malting crops or those suffering from stress, including high levels of stem base diseases. An alternative approach could be the use of Canopy at this stage which in trials has appeared less severe on the crop.
- As mentioned, crops treated with early chlormequat ± partner will need an ethephon-type treatment later. This can cause problems where the hope is to mix this later application with a fungicide but note that most of these products have a wide application window and treatment does not have to wait until GS49 (the very end of the window).
- **Medax Max** is also available for winter barley – see winter wheat growth regulator section. It can be used up to, and including, the end of booting.

T2:

- The higher doses (e.g. greater than 0.5 l/ha of Terpal) should be avoided in dry conditions or on stressed crops, however in wet seasons with appreciable stem extension between T1 and T2, the higher doses above may be needed.
- Canopy may also be considered as an alternative to Terpal in barley, but note that on malting crops it should be applied before GS32.
- Trinexapac-ethyl (e.g. Moddus) is approved up to GS41 in winter barley but will require higher doses at this later timing to be effective (i.e. 0.3 l/ha).
- Only one product containing 2-chloroethylphosphonic acid (ethephon) should be used in a programme.

c) Spring weed control

Grass-weed control

There are no effective herbicide options in winter barley for the control of **black-grass** or **bromes** in the spring.

Liberator (Regatta/Herold) can be applied after 31 December, up to fourth tiller stage (GS24) or 31 March if sooner, up to a maximum 0.3 l/ha (max. total for season 0.9 l/ha). Check label for further restrictions. At this dose it should give control of small meadow-grasses, but have limited effect on more difficult grass-weeds.

Pendimethalin or **pendimethalin + picolinafen** (e.g. Stomp Aqua, Anthem, Picona) can be used up to the end of tillering (before GS30).

Quirinus and Pontos (flufenacet + picolinafen) are also options before the end of tillering (GS30).

Axial Pro can be used for **wild-oat**, **rye-grass** and **rough-stalked meadow-grass** control up to crop GS41.

Foxtrot/Oskar can be used before crop GS31 for wild-oat or rough-stalked meadow-grass control.

Additional notes for grass-weed herbicide use

- ACC-ase inhibitors such as Topik, Axial etc: remember that a particular fop/dim/den can only be used once in a crop. Only use a second ACC-ase inhibitor to control different weeds at a different timing.
- Season total dose for **diflufenican** is **125 g/ha**, so this needs to be watched where more than one product containing this active is being used.

Broad-leaved weed control

Treatments following earlier herbicide applications: grass-weed programmes often cater for broad-leaved weeds also, except for treatment of cleavers and any spring germinators.

Compliance with the number of **ALS-inhibitor herbicides** that can be applied is usually the first consideration where additional broad-leaved weed control is needed following previous autumn herbicides. As a general rule, only two ALS-inhibitor products can be applied to a crop, with only one having grass-weed activity. There are some specific exceptions to this, and for broad-leaved weed control the main one is, products containing florasulam can be applied once in the autumn and again after 1 February provided the maximum total dose of 7.5 g a.i./ha is not exceeded.

Where resistance in broad-leaved weeds is known or suspected then mixing actives is very important.

Products

1. Cleavers

- Where no previous herbicide has affected their growth, healthy cleavers at low – moderate populations (3-10/m^2) should be treated by crop GS32. Lower cleaver populations, or where their growth has been severely affected by previous herbicides, can be left until crop GS37-39.
- Arylex products (Zypar and Pixxaro EC) are particularly effective (see *Zypar New Product Guide*, March 2017). Otherwise, products containing **both** fluroxypyr and florasulam tend to be more reliable in early spring than either, or amidosulfuron (e.g. Eagle) alone. **Broadway Star** also offers reliable activity on cleavers at this time. (Pixxaro EC and carfentrazone-ethyl products are mentioned in the non-ALS options section below).
- Be aware that there are large variations in the fluroxypyr:florasulam ratio in different products. Spitfire has the closest pre-formulated ratio and should therefore be more reliable at this timing than products such as Starane Gold or Starane XL, where the florasulam is contributing much less than the fluroxypyr as a partner herbicide.

- From mid-April or so, assuming better growing conditions, fluroxypyr, either alone or with florasulam or Arylex, can be used. If used straight, the rate of fluroxypyr should not be less than 150 g/ha. Note that authorisation for some fluroxypyr products ended during 2017 (e.g. Starane 2), but other straight fluroxypyr products are available (e.g. Hurler, Crescent). **Starane Hi-Load** will be the main option for straight fluroxypyr from Corteva Agriscience. At 0.45 l/ha, this offers similar weed control to 0.75 l/ha Starane 2.

2. Other broad-leaved weeds

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- **Zypar**, based on Arylex chemistry will also control a wide range of broad-leaved weeds. Control from Zypar includes some traditionally more difficult weeds, including crane's bill, fat hen, poppy, wild carrot, fumitory and cleavers. It shows a high degree of crop safety and is less sensitive to weather conditions than many other products, allowing earlier application when weeds are still small. Other florasulam-based products (e.g. **Spitfire**) also give effective control of a wide range of broad-leaved weeds.

- Straight florasulam (e.g. **Lector**). **Lector** can be used up to GS39 in winter wheat and winter barley. Maximum dose is 0.15 l/ha (of which up to 0.075 l/ha can be applied in the autumn). **Lector Delta** is also available (50 g/l florasulam + 500 g/l DFF), latest use is end of GS32.

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- Straight carfentrazone-ethyl (e.g. **Aurora 40 WG**) can also be used anytime up to before GS33, whilst carfentrazone + CMPP-p (**Platform S**) cannot be used before 1 March. Carfentrazone-ethyl provides useful control of speedwells and cleavers in particular.

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In most cases winter barley will be more competitive than winter wheat with weeds once spring growth starts. This will help herbicide performance, so lower doses can be considered. Lower doses will also help preserve crop safety, which is generally more of an issue in winter barley than winter wheat.

Check growth stages carefully: winter barley may well be a growth stage ahead of where it looks (e.g. already at GS31 when it looks like it may still be at GS30). It is also a good idea to treat fairly early, whilst the canopy is still open and weeds are accessible.

3. Spring barley

a) Nitrogen and sulphur

Total nitrogen dose

For both **feed** and **malting barley**; the optimum dose range (for SNS index 0) is similar:

100-150 kg/ha N

- Actual dose will be influenced by sowing date as highlighted by the 2017/18 season i.e. later sown crops will require less nitrogen. Variety choice will also influence actual dose e.g. RGT Planet does not respond to nitrogen applications and therefore can receive a lower dose whenever it is sown.
- For **malting barley**, applications of 100-150 kg/ha N should achieve 1.55-1.85% grain N (for an SNS index 0 soil); the higher end of this range has, in NIAB TAG trials, been fairly reliable in producing 1.65-1.85%, though this has varied with season and weather patterns.
- For grain N targets less than 1.55%, or for light sandy soils, total N doses between **80 and 125 kg/ha** are more appropriate.
- **Feed barley**; apply **100-150 kg/ha**, the lower figure being particularly appropriate for low yield potential or late drilled sites.
- With higher yield potential (**7.5 t/ha +**) doses greater than 150 kg/ha may be justified (and may still achieve malting quality) though any crop receiving more than 150 kg/ha is more likely to need a growth regulator even on lighter soils.

Timing

- Apply at least 50% of the total N dose pre- or 'peri-emergence' (GS10-11, usually as the tramlines become visible).
- The balance should be applied in a single dose any time before the end of tillering, or well before this if aiming for a low grain N market (e.g. distilling).
- Where very low total doses (less than 100 kg/ha N) are used e.g. low yielding sites, sites with very high residual N or in late-drilled crops (e.g. late March) then the nitrogen should be applied as a single dose pre- or peri-emergence.

Sulphur

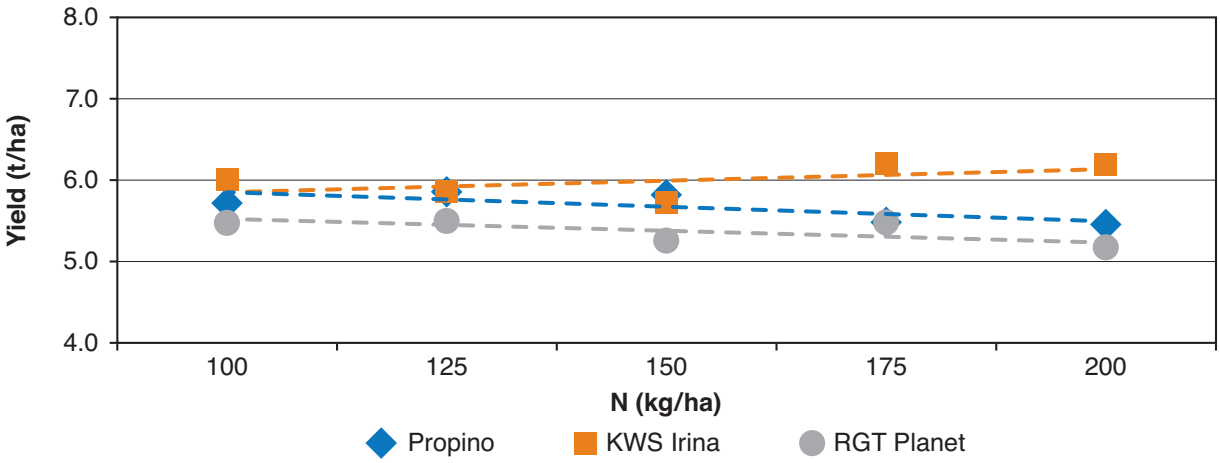
- Responses to sulphur application in this crop have been variable but significant responses have been seen on the lighter soils. If sulphur applications are planned for winter cereals then treatment of spring cereals should also be considered, around 25-38 kg/ha SO_3 (10-15 kg/ha S).

Malting quality in spring barley

- Optimum nitrogen doses needed for spring malting barley tend to be more consistent than in the winter crop. With a shorter growing season, seasonal weather patterns have less of an influence on the N dose needed in spring barley to attain malting. In past NIAB TAG trials even where the yield was limited (e.g. 2017) 150 kg/ha N proved to be a fairly reliable dose to maximise yield and achieve a target grain N of 1.65-1.85%. However in 2018 all grain Ns were high (Table 2). This was another result of the short growing season experienced and, whilst this result may not be repeated year on year, it does suggest that later sown crops can receive lower N applications.
- Grain N is more difficult to predict in dry springs, often exceeding 2% even with low N doses. On low yielding land, e.g. light sites in drier seasons, doses of 100-125 kg/ha N may well be more appropriate than those given above, similarly on heavier soils in drier seasons doses of 125-150 kg/ha N may be required.

- In wetter seasons particularly on stronger sites with good yield potential doses of 150-175 kg/ha N can be applied without compromising quality, though there will be an increased risk of lodging with such doses.

Figure 7. Nitrogen dose v yield, three varieties at Sutton Scotney 2018



For the last two years the trend lines have shown a fairly flat yield response to N for all varieties, in contrast to 2016 when the yields did not stop climbing in response to N dose (Figure 7). RGT Planet again showed a tendency for lower grain N for comparable applied N doses, compared to Propino and KWS Irina, though the differences were not as marked as in 2017 and 2016. Nevertheless the observation that, where N dose needs to be restricted, e.g. on heavier soils, this characteristic of the variety would be a useful attribute still holds.

Table 2. Grain N response to applied N in spring barley

Grain N levels recorded in a number of trials in 2017 and 2018, relative to applied N.

2017

N (kg/ha)	Hereford	Glos	Kent	Kent	Kent	Hants	Hants	Hants
	RGT Planet	RGT Planet	Propino	KWS Irina	RGT Planet	Propino	KWS Irina	RGT Planet
100	1.88	1.79	1.85	1.80	1.82	1.85	1.80	1.76
125	1.95	1.82	1.91	1.86	1.97	1.83	1.86	1.79
150	1.97	1.89	1.93	1.97	1.97	1.88	1.84	1.79
175	2.00	1.97	2.05	2.03	2.05	1.86	1.92	1.82
200	2.05	2.02	2.00	2.11	2.07	1.95	1.96	1.83

2018

N (kg/ha)	Hereford	Glos	Hants	Hants	Hants
	RGT Planet	RGT Planet	Propino	KWS Irina	RGT Planet
100	1.86	1.73	2.03	2.07	1.98
125	1.90	1.80	2.11	2.06	2.03
150	1.94	1.89	2.09	2.10	2.06
175	1.98	1.95	2.12	2.08	2.07
200	2.03	1.99	2.11	2.11	2.05

Grain N rose with increased applied N in 2017 trials in contrast to 2018 where grain N was generally higher but showed little or no response to applied N.

b) Growth regulation

Growth regulators

1. No treatment

Lodging control is not a routine measure for the majority of spring barley crops grown for malt. Some lodging was seen in 2017, less in 2018 but in both years brackling was more common. In most seasons those receiving traditional malting N doses, or those with limited potential on light land, are unlikely to lodge though some insurance against brackling may be justified.

2. In such cases, or

- where spring barley is grown on heavier soils than are traditional for this crop, or
- for any crop receiving more than 150 kg/ha N growth regulation should be considered:

Terpal 0.5-0.75 l/ha at GS32-39 (approved up to GS49)

This treatment would give a good measure of lodging control and some insurance against brackling in those varieties or crops which are susceptible (see notes below).

If the lodging risk is exceptionally high, a sequence may be needed, but again it is appropriate only for exceptional circumstances.

Other options include:

Chlormequat (1.25 l/ha) or **trinexapac 25-50 g a.i./ha** (e.g. Moddus 0.1-0.2 l/ha) at GS30, followed by Terpal 0.5 l/ha at GS37-49

The early PGR treatment (chlormequat and/or Moddus for example) may also be justified in conditions where tillering is restricted, for example following a cold late spring. In these, or any circumstances where tillering is restricted due to environmental, seedbed quality or other conditions, there may be a benefit from an early treatment to aid tiller survival.

Some, but not all, chlormequat products are approved for this crop. Check approvals before using.

As mentioned above, brackling (bending/kinking of the stem in the middle, leading to heads lying close to the ground) can occur in spring barley, for example as in 2017. This stem weakness well above the base is usually a factor of over-maturity leading to brittle stems and mainly resulting from a delayed harvest (again common in 2017). An additional influence would have been late N uptake (following a dry spring) as the final internodes were extending which caused excessive growth and hence weaker upper internodes.

Growth regulators have less influence on brackling than on lodging, but an application of the later-applied ethephon-based products, such as Terpal, will strengthen the upper stem and offset much of the brackling risk.

Table 3. Growth regulator programmes in spring barley at Cirencester (Glos)

This trial looked at a range of growth regulator inputs including potassium fertiliser to evaluate its value in straw strengthening and hence lodging control.

Treatment	GS25-30	GS32	GS32	Lodging (%)	Yield (t/ha)
1	Untreated	Untreated	Untreated	47	5.82
2	–	Terpal (0.5 l/ha)	–	7	5.83
3	–	Terpal (1.0 l/ha)	–	17	5.43
4	–	–	Terpal (0.5 l/ha)	37	5.04
5	–	–	Terpal (1.0 l/ha)	17	5.28
6	3C Chlormequat 750 (1.25 l/ha)	Terpal (0.5 l/ha)	-	30	5.24
7	3C Chlormequat 750 (1.25 l/ha)	Terpal (1.0 l/ha)	–	30	4.86
8	3C Chlormequat 750 (1.25 l/ha)	–	Terpal (0.5 l/ha)	27	5.22
9	3C Chlormequat 750 (1.25 l/ha)	–	Terpal (1.0 l/ha)	40	5.38
10	3C Chlormequat 750 (1.25 l/ha) Moddus (0.1 l/ha)	-	Terpal (0.5 l/ha)	23	5.37
11	3C Chlormequat 750 (1.25 l/ha) Moddus (0.1 l/ha)	–	Terpal (1.0 l/ha)	30	5.24
12	–	–	Canopy (0.75 l/ha)	47	4.99
13	K_2O (40 kg/ha)	–	–	17	5.75
			LSD	31	0.40
			CV %	–	4.49

Yields recorded in this trial were fairly closely related to lodging control. One of the lowest PGR inputs gave the best lodging control (Terpal 0.5 l/ha) and this trial showed that it can be applied at GS32 and there is no need to wait for first awns for application. The application of potassium fertiliser provided an interesting element to the trial and produced one of the highest yields as well as very respectable lodging control. Further data will be collected on applications of potassium fertiliser for this purpose before making firm recommendations. Higher PGR inputs, in the form of chlormequat and chlormequat + Moddus sequences with Terpal, were not required on this short-season crop (sown 20 April) and all of these significantly reduced yield compared with the untreated control.

c) Weed control

Herbicide programmes

- Many herbicide products can be used in spring barley and there are also a few useful EAMUs that improve the options for residual grass-weed control. The main options available are discussed below.
- Appropriate herbicide input will depend on a combination of sowing date and expected type and populations of weeds expected.
- In many cases, if drilling in March with 'average' levels of mainly broad-leaved weeds expected; a single herbicide by the early tillering stage should be sufficient.
- Where weed problems after the stem extension stage are expected (for example emergence of creeping thistles), ALS-inhibitor products will be useful here so it would be better to use a residual or non ALS-inhibitor product for early weed control, allowing the use of, for example, metsulfuron-methyl to be used up to GS41.
- Where very high populations of broad-leaved weeds are expected, use of a residual product after drilling will allow time to plan an appropriate follow-up herbicide without risking loss of yield through early weed competition.
- Where grass-weeds, including black-grass, are expected, plan to use as strong a residual product as possible.
- Where black-grass is a considerable issue then using Crystal (PDM + flufenacet) followed by Liberator (diflufenican + flufenacet) in sequence is an option as both products are available on EAMU and by using the doses recommended below the maximum permitted doses will not be exceeded. This, however, is an option that should be reserved for severe black-grass issues and in most situations, even where black-grass is a problem weed, should be avoided as spring barley provides strong competition against the weed and there is a risk of crop damage.
- For specific control of wild-oats, ACC-ase herbicides offer the best control, provided resistance to this mode of action is not a problem.

Grass-weed control – ACC-ase products

- **Axial Pro** (pinoxaden) is a good option for wild-oats, rough-stalked meadow-grass and rye-grass control in spring barley.
- **Foxtrot/Oskar** (fenoxaprop-P-ethyl) are also options for wild-oats and rough-stalked meadow-grass. Latest use though is before GS31.
- The products above may have activity on small black-grass, but resistance to their mode of action is widespread. All will give control of wild-oats, but again this depends on resistance status. Where populations of black-grass are significant, pre-emergence options are preferred.

Pre/early post-emergence

- **Avadex Excel 15G** or **Avadex Factor** (tri-allate) are especially useful if wild-oats are ACC-ase resistant. Pre-emergence only.
- **Defy** (prosulfocarb) (EAMU): up to three-leaf stage. Maximum dose 3.0 l/ha.
- **Pendimethalin products**: these are best applied pre-emergence of the crop. Some products do have clearance for post-em use though. Particular care may be needed when used late in the spring, during or prior to a period of very rapid growth.
- **Liberator/Regatta** (100 g/l DFF + 400 g/l flufenacet) (EAMU) – maximum dose 0.3 l/ha up to GS24. At this dose it should give good control of meadow-grasses, but have limited effect on other grass-weeds. Best used pre-emergence.
- **Herold** (200 g/l DFF + 400 g/l flufenacet) (EAMU) – maximum dose 0.15 l/ha to GS24, which will only deliver 60 g of flufenacet, so really a broad-leaved weed product with some annual meadow-grass activity. Best used pre-emergence.

- **Crystal** (300 g/l PDM + 60 g/l flufenacet) maximum dose 2.0 l/ha up to GS23. Comments as for Liberator (EAMU).
- **Pendimethalin + diflufenican** (Omaha 2) – up to before GS30, providing robust broad-leaved weed control and useful meadow-grass control.
- **Chlorotoluron + pendimethalin + diflufenican** (Tower/Tribal) – more emphasis on meadow-grass control than Omaha 2, pre-emergence only.

Cultural grass-weed control: this crop offers one of the best cultural control measures against black-grass but as more experience is gained it is worth considering any fine-tuning aspects which may improve it further. Although the late sowing (compared to winter cereals) helps considerably it is still important to achieve good seedbeds to allow prompt emergence and hence competition with weeds.

If using residual pre-emergence herbicides seedbed quality is particularly important, but this crop usually allows good seedbed preparation anyway: hence rolling after drilling may not be needed as often as it is with winter cereals. This could be important since it has been noticed that rolling can act as a further cultivation and hence stimulation for germination: lower black-grass numbers have been seen in un-rolled areas. Again, however, this assumes seedbed quality is still sufficient for residual herbicide performance. This detrimental effect from rolling is most likely to occur where there have not been other pre-drilling cultivations.

Also, drilling at a slower speed can often be a relatively easy and effective way of reducing additional soil disturbance.

Further weed control spectrum

- **Defy** has activity on cleavers, chickweed, speedwells, red dead-nettle, crane's-bill and black nightshade, as well as grass-weeds. Flufenacet + either pendimethalin or DFF will also have good broad-leaved weed activity.
- **Pendimethalin**: meadow-grasses plus a wide range of broad-leaved weeds. Dead-nettles, speedwells, and poppy are strengths; main weaknesses include polygonums, mayweeds and cleavers. See also in grass-weed herbicides above. Available in formulation with picolinafen (Chronicle, Pico Pro etc) with improved weed control.

Annual broad-leaved weed (BLW) control

- Typically, competitive populations of broad-leaved weeds need to be treated with an effective herbicide prior to the five leaf stage of early-drilled crops and the three-leaf stage of late drilled crops.
- ALS-inhibitor products (the sulphonylureas and florasulam) to date have been the most commonly used products for spring cereals being broad-spectrum and cost-effective. However, the threat of resistance is increasing and is already quite widespread in poppies, so use in mixtures with effective products that have a different mode of action should be used wherever possible. Newer chemistry in the form of Zypar and Pixxaro EC would also be more reliable in such cases and have greater flexibility in terms of timing (see *Zypar New Product Guide*).

Strength and weaknesses of main broad-leaved weed herbicide options

1. **Diflufenican** (DFF) (500 g/l) e.g. Hurricane SC – maximum dose 0.25 l/ha before end of February or 0.2 l/ha up to before GS32. Best used pre-emergence or by early tillering stage though. Broad spectrum of weeds controlled or partially controlled. Where the weed burden is expected to be high, this would allow much more flexibility on rates and timings of post-emergence follow-up herbicides, however use of this active would be discouraged, or at least the dose reduced significantly, where oilseed rape, stubble turnips or other brassicas will follow as residues may be an issue.
2. **Bromoxynil** (e.g. Maya) can be used alone (up to before GS32) but best used in mixture with mecoprop-P or ALS-inhibitor products to boost weed control reliability and as part of an anti-resistance strategy.
3. **Mecoprop-P**: cleavers, chickweed, shepherd's purse, fat-hen, charlock and others. Like bromoxynil and fluroxypyr, adds significantly to the weed spectrum when added to ALS-inhibitor products. Apply before GS31.

4. **Other phenoxy herbicides** – some products containing various amounts of actives such as MCPA, 2, 4-D and dichlorprop-P can also be used in spring barley, but great care needs to be taken that they are not applied beyond the label's latest growth stage, which is before GS31 in most cases.

5. **Carfentrazone ± mecoprop** (e.g Aurora, Platform S) good control of cleavers and speedwells. Can show crop scorch, especially if tank mixes outside the limited backed list are not followed. Apply up to end of GS32; but not before 1 March for products containing mecoprop-P.

6. **Clopyralid** (e.g. Dow Shield 400) mayweeds, corn marigold and some other weeds. Useful tank mix partner and also as part of an ALS-inhibitor anti-resistance strategy. Apply after 1 March and up to end of GS32.

7. **Fluroxypyr** (Starane Hi-Load etc): cleavers, chickweed, black-bindweed, dead-nettle and others.

8. **Clopyralid + florasulam + fluroxypyr** (e.g. Galaxy, Dakota): cleavers, chickweed, mayweeds, brassica weeds, black-bindweed, corn marigold, knotgrass, pale persicaria, poppy and others.

9. **Florasulam + fluroxypyr** 5 g/l + 100 g/l (e.g. Spitfire): black bindweed, chickweed, brassica weeds, cleavers, corn marigold, groundsel, mayweeds, poppy, forget-me-not, hemp nettle, dead nettles, knotgrass, pale persicaria.

10. **Florasulam + fluroxypyr** 2.5 g/l or less + 100 g/l (Starane XL): as above but with less spectrum of weed activity.

11. **Florasulam** (e.g. Lector) up to the end of GS39. Cleavers, groundsel, mayweeds plus other weeds.

12. **Florasulam + diflufenican** (e.g. Lector Delta) up end of GS32. A useful combination of residual and contact modes of action.

13. **Florasulam + tribenuron-methyl** (Bolt) from 15 March to end of GS32. Broader spectrum than each active used separately.

14. **Metsulfuron-methyl** (e.g. Jubilee SX, Accurate, Savvy Premium): wide range of broad-leaved weed control, if weeds treated when small. Main weaknesses are cleavers, ivy-leaved speedwell, black-bindweed, black nightshade, fumitory and fat hen. Late application will provide some control of perennial weeds such as docks and thistles.

15. **Tribenuron-methyl** (Thor, Triad): broad spectrum weed control, but not as strong as metsulfuron-methyl. Improved activity on fumitory and groundsel though.

16. **Metsulfuron-methyl + thifensulfuron-methyl** (e.g. Harmony M SX, Ergon): improved polygonum control over straight metsulfuron and some cleaver activity (moderately susceptible).

17. **Metsulfuron-methyl + tribenuron-methyl** (e.g. Ally Max SX, Boudha, Traton SX): increases the size of weeds controlled by straight metsulfuron and adds some fumitory and improved groundsel control.

18. **Metsulfuron-methyl + diflufenican** (Pelican Delta). Useful complementary weed spectrum but see comments for diflufenican above.

19. **Thifensulfuron-methyl + tribenuron-methyl** (e.g. Hiatus, Inka SX) products also have a useful weed spectrum (brassicas, some polygonums, mayweed, poppy etc).

20. **Amidosulfuron** (e.g. Eagle): cleavers, forget-me-not, charlock, shepherd's purse.

21. **Arylex + florasulam** (Zypar): broad weed spectrum including difficult weeds such as umbelliferae, crane's bill, fat hen, poppy, fumitory black bindweed and cleavers. Also controls mayweed, brassicas and other weeds.

22. **Arylex + fluroxypyr** (Pixxaro): GS13-GS45. A non-ALS-inhibitor option, with good weed spectrum including crane's bill, fumitory, cleavers, poppy, black bindweed and fat hen. However, will not control brassica species. Tank mixes available with dicamba or SUs to broaden spectrum. Add mineral oil for best results.

4. Spring wheat

a) Nitrogen and sulphur

Total nitrogen dose

- Light and medium soils (N index 0): **150-175 kg/ha**
- Heavier/more fertile soils or later sowing (late March onwards): **125 (-150) kg/ha**

  Most crops are grown for quality so these totals should help achieve target grain protein.

  In both situations higher doses can be applied if yield potential is good provided the lodging risk is not significant.

Timing:

- **Spring sown crops:** apply 50-75% of the total dose pre- or early post-emergence (when tramlines visible), and the balance by early stem extension (GS30-31). The higher proportion in the first dose is relevant to later sowings (mid-March onwards).
- Delaying the second application to GS32 can improve grain protein but in dry springs uptake may be compromised, losing both yield and quality.
- If a specific treatment to boost grain quality is needed, an additional 30-40 kg/ha N may be applied as foliar urea at the milky ripe stage.
- **Autumn sown crops:** the dose and timings would be as for winter wheat (section 1).

Sulphur

- Responses to sulphur in spring cereals have been variable but will likely reflect responses in winter crops. On light soils, if sulphur applications are planned for winter cereals then treatment of spring wheat should also be considered, around 10-15 kg/ha S (25-38 kg/ha SO_3) but no more. Excessive winter rainfall will also pre-dispose crops towards sulphur deficiency

b) Growth regulation

Spring-sown crops grown on light soils do not usually require growth regulation

On heavier soils, or on lighter soils where rainfall prior to GS30 has allowed prompt uptake of applied nitrogen, chlormequat can be applied as an insurance measure:

Chlormequat 1.0 l/ha (~750 g a.i./ha) up to end of GS31 (i.e. prior to GS32)

or **Moddus 0.1-0.2 l/ha** (up to before GS33)

Either would be best applied at GS30-31. A mix of the two would be a stronger PGR option but spring sown spring wheat should not need this level of input and it may be harsh on the crop.

Autumn sown crops on fertile soils may however need this higher input.

As with spring barley (section 3) the above treatments may also be beneficial, irrespective of any lodging risk, when seedbed or environmental conditions restrict tillering, in restricting further tiller loss.

Medax Max is also approved for spring wheat. NIAB TAG does not have any trial data on its performance.

c) Weed control

Herbicide programmes

- There is a wide range of products that can be used in spring wheat and there are also a few EAMUs that give options for residual grass-weed control. However, there are no single product options that will give strong levels of residual grass-weed control for weeds like black-grass and rye-grass.
- How much herbicide input is appropriate will largely depend on a combination of sowing date and expected type and populations of weeds expected. Spring wheat will offer less crop competition to weeds than spring barley, so herbicide programmes need also to take this into account (less opportunity for cutting dose).
- Where weed problems after the stem extension stage are expected (e.g. emergence of creeping thistles), it will probably be useful to rely on a residual or non ALS-inhibitor product for early weed control, allowing the use of an ALS-inhibitor such as metsulfuron-methyl to be used at the end of stem extension.
- Where very high populations of broad-leaved weeds are expected, use of a residual product after drilling will allow time to plan an appropriate follow up herbicide without risking loss of yield through early weed competition.
- For grass-weed control plan to use as strong a residual product mix as possible.
- For control of wild-oats, ACC-ase herbicides offer the best control, provided resistance to this mode of action is not a problem.

Grass-weed control

1. Pre/early post-emergence

- **Liberator/Regatta.** This has full approval for spring sown spring wheat, at a maximum dose of 0.3 l/ha, from pre-emergence up to GS12 (2-leaf).
- **Pendimethalin products:** Several have EAMUs for use up to GS30 (Anthem, Cinder, Stomp 400 and others) though they are best applied pre-emergence of the crop. Particular care may be needed when used late in the spring, during or prior to a period of very rapid growth. Some pendimethalin + picolinafen products (e.g. Chronicle, Orient) also have EAMUs, pre-emergence timing only.
- **Herold** (200 g/l DFF + 400 g/l flufenacet) maximum dose 0.15 l/ha to GS23, which will only deliver 60 g of flufenacet, so really a broadleaved weed product with some annual meadow grass activity. Best used pre-emergence. (EAMU)
- **Pendimethalin + diflufenican** (Omaha 2) – up to before GS30, providing robust broad-leaved weed control and useful meadow grass control.
- **Chlorotoluron + pendimethalin + diflufenican** (Tower/Tribal) – more emphasis on meadow grass-weed control than Omaha 2, pre-emergence only.
- **Avadex Excel 15G** has approval for spring wheat (MAPP no. 17872). Pre-emergence only.

2. ACC-ase products

These may also have activity on small black-grass, but resistance to their mode of action is almost ubiquitous.

- **Clodinafop-propargyl** (e.g. Topik, Sword) is probably the best option in spring wheat, giving control of wild-oats, Italian rye-grass and rough-stalked meadow grass.
- **Foxtrot/Oskar and Polecat** (fenoxaprop-P-ethyl) are also options for wild-oats and rough-stalked meadow grass. Latest use GS39.
- **Axial Pro** (pinoxaden) can also be used for wild-oats, rough-stalked meadow-grass and rye-grass control. This will be the best option if rye-grass is the main target weed.

3. ALS-inhibitors

- **Broadway Star (/Palio)** can be used on spring wheat (between GS31 and GS32) for wild oat and broadleaved weed control, up to a maximum of 200 g/ha (+ adjuvant). There is an EAMU for use of Atlantis in spring wheat, but only those crops sown before 1 February.

Annual broad-leaved weed (BLW) control

- As with other spring cereal crops, competitive populations of broad-leaved weeds need to be treated with an effective herbicide prior to the five-leaf stage of early-drilled crops and the three-leaf stage of late drilled crops.
- ALS-inhibitor products (the sulfonylureas and florasulam) tend to be the most broad-spectrum and cost-effective products for spring cereals. However, the threat of resistance is increasing and is already quite widespread in poppies, so use in mixtures with effective products that have a different mode of action should be used wherever possible.

Strength and weaknesses of main broad-leaved weed herbicide options

1. **Diflufenican** (DFF) (500 g/l) e.g. Hurricane SC. maximum dose 0.25 l/ha before end of February or 0.2 l/ha up to before GS32. Best used pre-emergence or by early tillering stage though. Broad spectrum of weeds controlled or partially controlled. Where the weed burden is expected to be high, this would allow much more flexibility on rates and timings of post-emergence follow-up herbicides. However, use of this active would be discouraged, or at least the dose reduced significantly, where oilseed rape, stubble turnips or other brassicas will follow as residues may be an issue.
2. **Pendimethalin:** meadow-grasses plus a wide range of broad-leaved weeds. Dead-nettles, speedwells, and poppy are strengths; main weaknesses include polygonums, mayweeds and cleavers.
   See also in grass-weed herbicide section above.
3. **Arylex + florasulam** (Zypar): broad weed spectrum including difficult weeds such as umbelliferae, crane's bill, fat hen, poppy, fumitory, black bindweed and cleavers. Also controls mayweed, brassicas and groundsel.
4. **Mecoprop-P:** cleavers, chickweed, shepherd's purse, fat-hen, charlock and others. Like bromoxynil and fluroxypyr, adds significantly to the weed spectrum when added to ALS-inhibitor products. Apply before GS31.
5. **Other phenoxy herbicides** – some products containing various amounts of actives such as MCPA, 2, 4-D and dichlorprop-P can also be used in spring barley, but great care needs to be taken that they are not applied beyond the label's latest growth stage, which is before GS31 in most cases.
6. **Carfentrazone ± mecoprop** (e.g. Aurora, Platform S) good control of cleavers and speedwells. Can show crop scorch, especially if tank mixes outside the limited backed list are not followed. Apply up to end of GS32, but not before 1 March for products containing mecoprop-P.
7. **Clopyralid** (e.g. Dow Shield 400) mayweeds, corn marigold and some other weeds. Useful tank mix partner and also as part of an ALS-inhibitor anti-resistance strategy. Apply after 1 March and up to end of GS32.
8. **Fluroxypyr** (Starane 2, Starane Hi-Load): cleavers, chickweed, black-bindweed, dead-nettle and others.
9. **Clopyralid + florasulam + fluroxypyr** (e.g. Galaxy, Dakota) cleavers, chickweed, mayweeds, brassica weeds, black-bindweed, corn marigold, knotgrass, pale persicaria, poppy, plus in addition control of some ALS-inhibitor resistant chickweed mayweed and poppy.
10. **Florasulam + fluroxypyr** 5 g/l + 100 g/l (e.g. Spitfire): black bindweed, chickweed, brassica weeds, cleavers, corn marigold, groundsel, mayweeds, poppy, forget me not, hemp nettle, dead nettles, knotgrass, pale persicaria; plus in addition control of ALS-resistant chickweed (both mutations) plus mayweeds and poppy (Proline 197 mutation).
11. **Florasulam + fluroxypyr:** 2.5 g/l or less + 100 g/l (Starane XL/Gold): as above but with less spectrum of weed activity.
12. **Florasulam** (e.g. Lector, Boxer) up to the end of GS39. Cleavers, groundsel, mayweeds plus other weeds.

13. **Metsulfuron-methyl** (e.g. Jubilee SX, Savvy Premium): wide range of broad-leaved weed control, if weeds treated when small. Main weaknesses are cleavers, ivy-leaved speedwell, black-bindweed, black nightshade, fumitory and fat hen. Late application will provide some control of perennial weeds such as docks and thistles.

14. **Tribenuron-methyl** (e.g.Thor): broad spectrum weed control, but not as strong as metsulfuron-methyl. Improved activity on fumitory and groundsel though.

15. **Metsulfuron-methyl + thifensulfuron-methyl** (e.g. Harmony M SX, Ergon): improved polygonum control over straight metsulfuron and some cleaver activity (moderately susceptible).

16. **Metsulfuron-methyl + tribenuron-methyl** (e.g. Ally Max, Boudha, Traton SX): increases the size of weeds controlled by straight metsulfuron and adds some fumitory and improved groundsel control.

17. **Amidosulfuron** (e.g. Eagle): cleavers, forget-me-not, charlock, shepherd's purse.

18. **Bromoxynil** (e.g. Maya, Flagon) can be used alone (up to before GS32) but best used in mixture with mecoprop-P or ALS-inhibitor products to boost weed control reliability and as part of an anti-resistance strategy.

19. **Arylex + fluroxypyr** (Pixxaro): GS13-GS45. A non-ALS-inhibitor option, with good weed spectrum including crane's bill, fumitory, cleavers, poppy, black bindweed and fat hen. However, it will not control brassica species. Tank mixes available with dicamba or ALS-inhibitors to broaden spectrum. Add mineral oil for best results with difficult weeds.

Cultural control of weeds can be achieved with robust seed rates (see section 10) and higher nitrogen doses (with possible corresponding use of PGRs). This may be particularly relevant where the crop is used as part of a black-grass control strategy.

5. Oats (winter and spring)

a) Nitrogen

Total dose (winter and spring crops)

50-160 kg/ha N

- This is a very wide range though most total doses are in the range 100-150 kg/ha N (winter) and 80-125 kg/ha N (spring). With oats, the optimum nitrogen can vary widely based primarily on soil fertility and crop structure in early spring. Lodging risk is the main influence, and therefore the straw stiffness rating of the variety should also be considered.
- Oats do not have an N max limit in NVZs, whilst wheat and barley do.

Timing

- **Apply 30-40 kg/ha N** during tillering – start of stem extension (late February-early March) and the balance once stem extension has started (GS31-32) in April. If the crop is well-tillered, consider missing the first timing and applying the total as one dose later. Also, where less than, say, 80 kg/ha is judged to be required in total, this is best applied as a single dose at the second timing.
- For **spring oats**, where experience with the crop is good and no more than 80-100 kg/ha are planned to be applied, the entire nitrogen dose can be applied pre- or early post-emergence (tramlines visible). Where experience with the crop, or soil nitrogen supply is less certain, applying 30-40 kg/ha early, and the balance once the crop has reached the mid to end of tillering stage (GS30), is a better option.

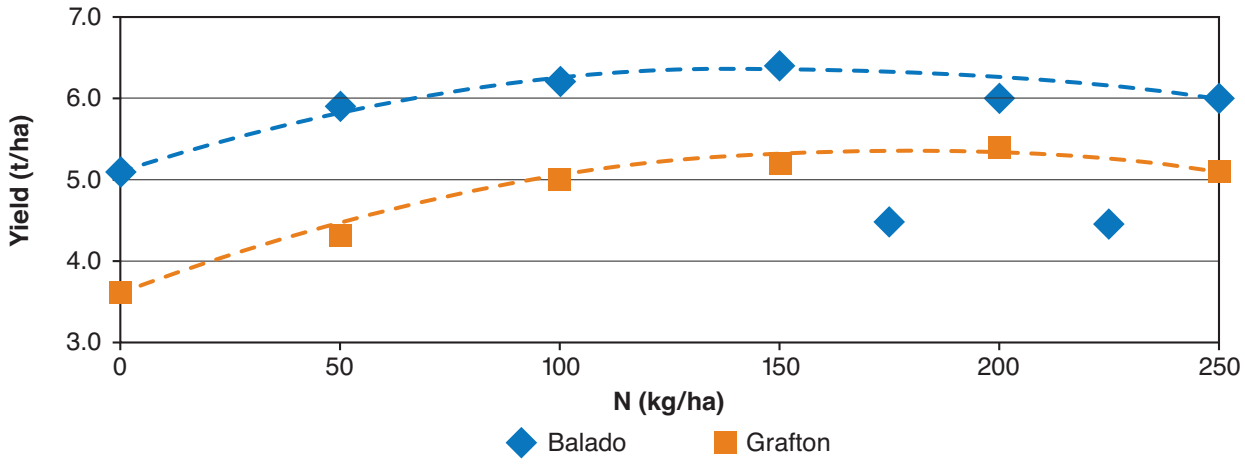
Sulphur

- As with all other cereals the oat crop may suffer sulphur deficiency in a number of situations, and is unlikely to be grown in association with regular uses of manure, hence a routine 25-38 kg/ha SO_3 (10-15 kg/ha S) should be included with the first N dose.

Dense, well established crops of winter oats on higher than average fertility soil will require the least nitrogen. Crops that are less dense (have no more than 50-70% ground cover in March), are one of the stiffer-strawed varieties (e.g. Balado) and are on land with low residual nitrogen (less than 50 kg/ha), can be given up to 140 kg/ha, or even up to 160 kg/ha with a good deal of caution, if lodging risk is judged to be low enough.

A three-year trial series, discussed in detail in the 2017 *Strategic Agronomy Handbook* (Nitrogen dose response in winter oats – page 17), showed a fairly consistent trend for yields to level off from 100 kg/ha. The results from the trial at Cirencester in 2016 are typical and are shown in Figure 8.

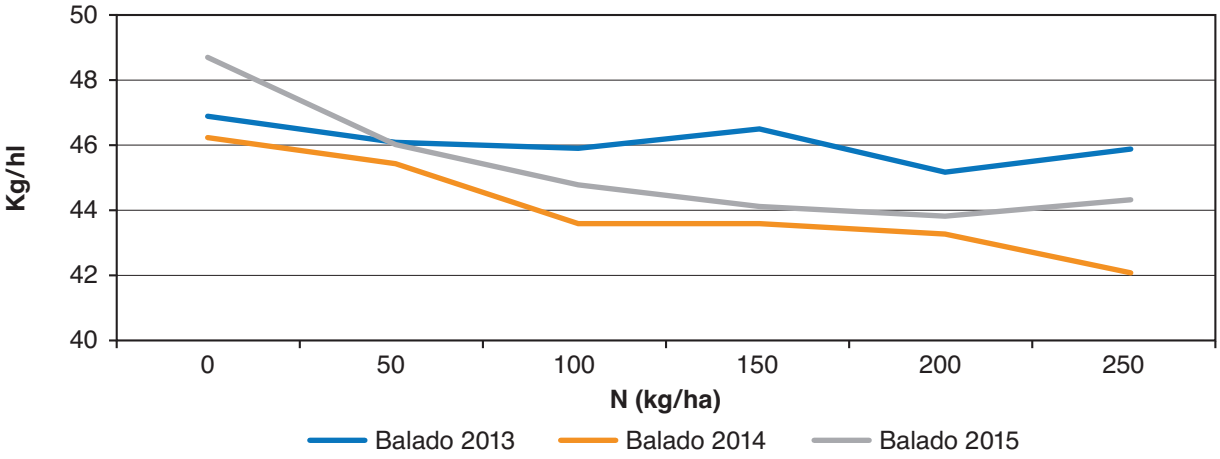
Figure 8. Nitrogen dose response in winter oats. Cirencester 2016



(A similar trial on spring oats, again on light soil at Cirencester, showed no levelling-off in yield up to 150 kg/ha N. No lodging was recorded in this trial, indicating again how yield potential can be limited in this crop if it lodges).

As discussed in the article in the *Strategic Agronomy Handbook*, in this trial series increasing N dose had a fairly consistent negative effect on specific weight.

Figure 9. Effect of N dose on specific weight. Balado, three year data



Figures for Grafton showed similar trends.

b) Growth regulation

Growth regulators

Whether a crop lodges or not is often the major limiting factor to yield and quality in oat crops. Oats are also more sensitive to agrochemicals, especially growth regulators and herbicides, than other cereals. Many manufacturers do not support as many tank mixes in oats as they do in wheat and barley, especially tank mixes of herbicides and growth regulators. Additional care should therefore always be taken to check if tank mixes are supported or not.

Suggested programmes

Winter oats

- **1.0-2.0 l/ha chlormequat** (750-1,500 g a.i./ha) at GS32. (Check grower's contract allows chlormequat use).
- Alternatively a split: **750g a.i./ha chlormequat** at GS30-31 followed by a **further 750 g a.i./ha chlormequat** at GS32, where the lodging risk is high.
- If it is felt that higher input is needed, an alternative is to use a mixture of a half dose chlormequat and half dose trinexapac-ethyl at GS30-31, allowing a further half dose of chlormequat to be applied at GS32 if necessary:
- **1.0 l/ha chlormequat** (750 g a.i./ha) **+ 25-50 g a.i./ha trinexapac-ethyl** (e.g. 0.1-0.2 l/ha Moddus, 0.15-0.3 l/ha Optimus, approx.) at GS30-31, followed if necessary by **a further 750g a.i./ha chlormequat** at GS32.
- Note that mixing trinexapac-ethyl products with chlormequat is not supported for oats by all manufacturers, especially in spring oats.
- In general, high input PGR programmes can reduce bushel weight so try to reduce the need for these by careful nitrogen management.
- Where **chlormequat is not permitted**.

Spring oats

- Growth regulators are not always needed as lodging risk is lower in the spring crop, but where there is considered to be a risk, apply between half and full rate chlormequat at GS31-32, again taking account of any restrictions on its use in contracts.

  750-1,500 g a.i. /ha chlormequat at GS31-32.

For both winter and spring crops, if not able to use chlormequat, apply

50-75 g/ha trinexapac-ethyl at GS30-31 (Moddus 0.2-0.3 l/ha, Optimus 0.3-0.45 l/ha approx.) As above, these treatments may have effects on grain quality so it may be safer to use less nitrogen and hence lower doses of trinexapac-ethyl.

Growth regulators – additional comments and products

- Latest stage for application of chlormequat is 'before GS33', with best activity coming from applications at GS32. Some products also specify the addition of an approved non-ionic wetter at up to 25 ml/100 litres of final spray solution if being applied alone to oats.
- Some products can only be applied once to oats. If a split application is required, the product used must either have approval for more than one application, or different products will need to be used for each application.
- **Trinexapac-ethyl** tends to be less predictable in its effect than chlormequat-based products, so should be used cautiously and not beyond the latest growth stage approved on the label (up to GS31). Rates above 75g a.i./ha should only be used if the crop is robust enough and lodging risk judged to be high enough. Splitting the total application between GS30 and GS31 is also an option.
- **Medax Max** (prohexadione-calcium + trinexapac-ethyl MAPP 17263) offers another chlormequat-free treatment for winter oats. Like Moddus it can be used alone or mixed with chlormequat. Typical doses would be 0.2 kg/ha when mixed with chlormequat, or 0.2-0.3 kg/ha used alone. It can be applied from end of tillering (GS29) to flag leaf (GS39). (It can be used on spring oats but due to crop sensitivity lower doses than those mentioned would be advisable).
- **Canopy** (mepiquat chloride + prohexadione-calcium, MAPP 16314) can also be used on oats. Hence this product would be another option for the oat crop, though it contains mepiquat so is not totally 'quat-less'. As with other cereals it can be used up to GS39 ('before GS41') though some crop effects have been seen with treatments after GS33. Suitable doses would be 0.3 l/ha if mixed with chlormequat or 0.3-0.5 l/ha used alone.

Cultural control of lodging

- Growth regulator options for the oat crop are restricted and crop damage can be caused more easily than in wheat or barley. Crops should therefore be managed so that the reliance on growth regulators is minimised. This means that other measures to reduce lodging risk, particularly nitrogen management (see above), are more important than with wheat or barley.
- **Variety choice**: lodging resistance scores for winter oat varieties on the AHDB Recommended List range from 3 (e.g. Dalguise) to 8 (e.g. Fusion), so variety choice can make a significant contribution to the cultural control of lodging. The range for spring varieties is smaller.
- **Plant population**: as with wheat, avoiding having over thick crops will help reduce lodging risk.
- **Nitrogen management**: avoiding large doses of nitrogen before stem extension has started (GS31) will help prevent increasing lodging risk linked to straw growth. Well-tillered crops should not receive any nitrogen until mid-April if lodging risk is high.

c) Weed control

Herbicide programmes

Grass-weed control

Herbicide options are very restricted and where significant grass weed populations are expected oats should not be grown. For the **spring crop** pre-drilling glyphosate treatment will help and of the broad-leaved weed control options listed below, **diflufenican** will have some grass weed activity, particularly meadow grasses, though it should not be relied on to control moderate-high numbers of grass-weeds.

- For **winter oats**, of the grass-weed control options available in the autumn, **Excalibur** (diflufenican plus flupyrsulfuron) under EAMU 1776/17, and **Absolute** (similar a.i.s, EAMU 2058/17) can be used in spring, up to (i.e. before) GS23 and before the end of March (winter oats only). This can only be applied in the spring if no flupyrsulfuron containing products were used in the autumn. Note that products containing flupyrsulfuron can no longer be sold and needed to be used by 13 December 2018.
- **Spring oats** are particularly prone to phytotoxicity so care is needed with all sprays. If possible do not mix more than two products in one application, particularly herbicides, and try to complete weed control before later sprays (fungicides, PGRs) are needed.

Annual broad-leaved weed (BLW) control

- Oats tend to offer good levels of crop competition against weeds and can also delay emergence of weeds, so there is more opportunity to reduce rates and also wait a little longer before applying the main spring herbicide. Even so, aim to apply before the end of tillering growth stage.
- ALS-inhibitor products (the sulfonylureas and florasulam) tend to be the most broad-spectrum and cost-effective products for spring weed control in general. However, the threat of resistance is increasing and is already quite widespread in poppies, so their use in mixtures with effective products that have a different mode of action should be considered wherever possible. In oats however, the number of tank mixes backed by manufacturers is a lot less than in wheat or barley mainly, as discussed above, due to crop safety issues.

There is a wide range of products for broad-leaved weeds that can be used in oats, but not as many as in wheat or barley. See page 38 for comments on the main options available.

Product choice and how much herbicide input is appropriate will largely depend on a combination of sowing date and the expected type and populations of weeds.

In many cases, if drilling spring oats in March with 'average' levels of mainly broad-leaved weeds expected a single herbicide by the mid-late tillering stage should be sufficient. Note that tank mix flexibility is often less when products are used in oats and latest timings of use are sometimes sooner than in barley or wheat.

Where very high populations of broad-leaved weeds are expected, use of a residual product (diflufenican) after drilling will allow time to plan an appropriate follow-up herbicide without risking loss of yield through early weed competition.

Strength and weaknesses of main broad-leaved weed herbicide options

Non ALS-inhibitor options

1. **Diflufenican** (DFF) (500 g/l) EAMUs for some products (e.g. Hurricane SC) – maximum dose 0.25 l/ha before end of February or 0.2 l/ha up to before GS32. As mentioned, **spring oats** in particular can suffer phytotoxicity quite readily so for these a maximum dose of 0.125 l/ha would be advisable. Best used pre-emergence or by early tillering stage. A broad spectrum of weeds is controlled or partially controlled. Where the weed burden is expected to be high, this would allow much more flexibility on rates and timings of post-emergence follow-up herbicides.

2. **Bromoxynil** (e.g. Maya) can be used alone (up to before GS32) but best used in mixture with mecoprop-P or ALS-inhibitor products to boost weed control reliability and as part of an anti-resistance strategy.

3. **Mecoprop-P**: cleavers, chickweed, shepherd's purse, fat-hen, charlock and others. Like bromoxynil and fluroxypyr, adds significantly to the weed spectrum when added to ALS-inhibitor products. Apply before GS31.

4. **Other phenoxy herbicides** – some products containing various amounts of actives such as MCPA, 2, 4-D and dichlorprop-P can also be used, but great care needs to be taken that they are not applied beyond the label's latest growth stage, which is 'before GS31' in most cases.

5. **Carfentrazone ± mecoprop** (e.g. Aurora, Platform S) good control of cleavers and speedwells. Can show crop scorch, especially if tank mixes outside the limited backed list are not followed. Apply up to end of GS32, but not before 1 March for products containing mecoprop-P.

6. **Clopyralid** (e.g. Dow Shield 400) mayweeds, corn marigold and some other weeds. Useful tank mix partner and also as part of an ALS inhibitor anti-resistance strategy. Apply after 1 March and up to end of GS32.

7. **Fluroxypyr** (Crescent, Starane Hi-Load): cleavers, chickweed, black-bindweed, dead-nettle and others. Apply before GS32.

ALS + non ALS-inhibitor formulated product options

8. **Clopyralid + florasulam + fluroxypyr** (e.g. Galaxy, Dakota) cleavers, chickweed, mayweeds, brassica weeds, black-bindweed, corn marigold, knotgrass, pale persicaria, poppy. Apply before GS32.

9. **Florasulam + fluroxypyr** 5 g/l + 100 g/l (e.g. Spitfire): black bindweed, chickweed, brassica weeds, cleavers, corn marigold, groundsel, mayweeds, poppy, forget-me-not, hemp nettle, dead nettles, knotgrass, pale persicaria. Apply before GS32.

ALS-inhibitor only products (single and multiple actives)

10. **Florasulam** (e.g. Lector, Boxer) up to the end of GS39. Cleavers, groundsel, mayweeds plus other weeds.

11. **Florasulam + tribenuron-methyl** (Bolt) from 15 March to end of GS32. Broader spectrum than each active used separately.

12. **Metsulfuron-methyl** (e.g. Jubilee SX): wide range of broad-leaved weed control, if weeds treated when small. Main weaknesses are cleavers, ivy-leaved speedwell, black-bindweed, black nightshade, fumitory and fat hen. Late application will provide some control of perennial weeds such as docks and thistles.

13. **Tribenuron-methyl** (e.g. Thor): broad spectrum weed control, but not as strong as metsulfuron-methyl. Improved activity on fumitory and groundsel though.

14. **Metsulfuron-methyl + thifensulfuron-methyl** – only some products (e.g. Ergon): improved polygonum control over straight metsulfuron and some cleaver activity (moderately susceptible).

15. **Thifensulfuron-methyl + tribenuron-methyl** – only some products (e.g. Inka SX): similar activity to metsulfuron-methyl + thifensulfuron-methyl.

16. **Metsulfuron-methyl + tribenuron-methyl** (e.g. Ally Max): increases the size of weeds controlled by straight metsulfuron and adds some fumitory and improved groundsel control.

17. **Amidosulfuron** (e.g. Eagle): cleavers, forget-me-not, charlock, shepherd's purse.

Products containing Arylex, e.g. Pixxaro EC and Zypar are **not** authorised for use in oats.

Cultural control: pre-drilling treatment with glyphosate is the main alternative for non-selective chemical weed control. Inter-row harrowing can also be an effective way for controlling weeds, especially broad-leaved weeds if soil type and conditions come at the right time. This technique is likely to work best on lighter textured and more free draining soil types. Dry conditions for a period following harrowing are required and more than one pass may be required as well.

6. Winter oilseed rape

a) Nitrogen and sulphur

Total nitrogen dose

220-240 kg/ha N

Lower total doses can be justified for yield potential and/or canopy size:

- Large canopies with GAI 1 or more at the start of spring growth, or lower yield potential (up to 3 t/ha): **200 kg/ha**
- Exceptionally large canopies: **160 kg/ha**

Timing

Normal crops

For 'normal' crops consider two applications as a 50:50 split of the total around late rosette and early stem extension (typically late February and mid to late March). Exact timing and individual doses are not critical however and it is more important to ensure that N is applied in conditions conducive to uptake rather than being guided by calendar date.

Backward crops

This includes those still recovering from flea beetle damage, or those sown late to replace lost crops. Prompt delivery of nitrogen is important hence timing is more critical and these should be a priority for treatment, in particular with first doses.

With backward crops a three-way split might be advantageous to provide a prompt dose in early spring (mid February) minimising the risk of leaching but encouraging early growth.

Forward crops

If the crop is excessively developed in early spring then careful management of the canopy can be beneficial, for example by applying a smaller first dose and holding back a main dressing (this in addition to the total dose adjustment above).

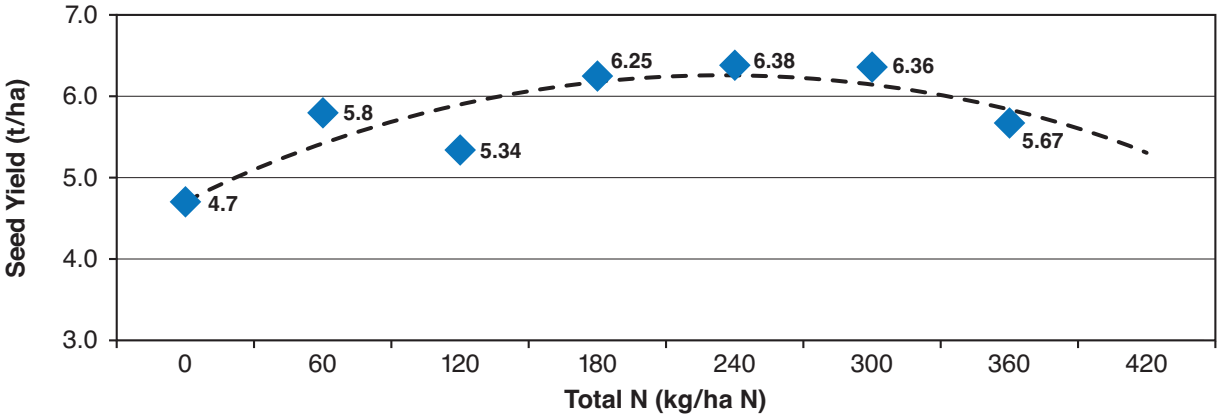
Missing the first dose altogether runs the risk of no nitrogen being available before a possible spring drought starts. It will also delay delivery of sulphur.

Sulphur

Apply **75-100 kg/ha SO_3** (30-40 kg/ha S) to all rape crops in early spring, ideally all or most with the first N dose.

- In NVZs make sure the total nitrogen dose does not exceed the Nmax value for the crop.
- Although canopy management is perhaps more relevant to rape than other crops, the range in optimum total N dose is not large. Large-canopy crops have already captured more N in the plant and less is left in the soil for spring growth, so what is needed for this will have to be applied. Conversely smaller canopies still have some growing to do and it cannot be assumed that unused soil supplies can provide sufficient N.
- If significant N leaching is suspected, for example following an excessively wet winter, also if there has been severe pigeon grazing where nitrogen captured in the canopy is lost from the system, more applied N will be needed, overriding canopy size considerations.
- Recent NIAB TAG nitrogen response trials show the optimum total is still around 200-240 kg/ha. Oil content can be reduced at higher N doses so care is needed if contemplating these.
- Figure 10 shows a typical response curve from the NIAB TAG trial database.

Figure 10. Nitrogen response in oilseed rape, Cambridge, Morley 2015



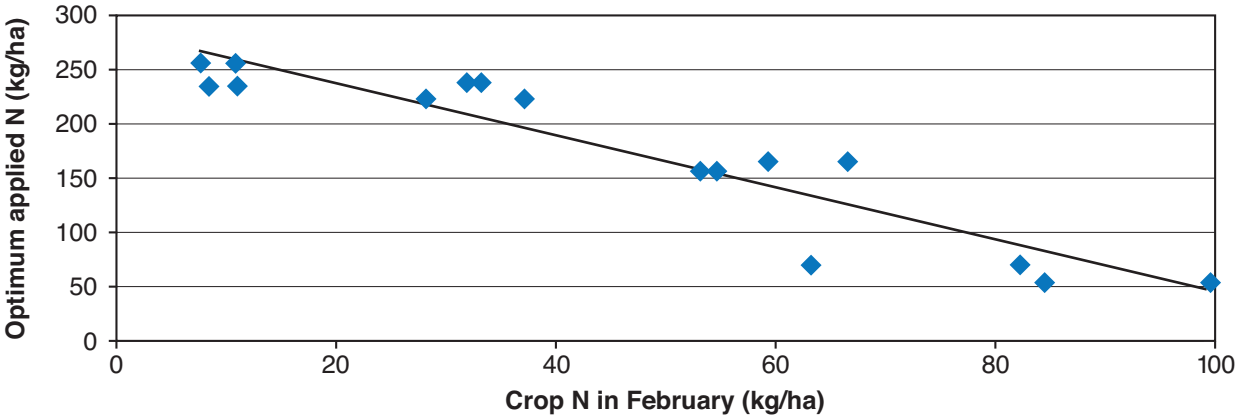
Timing of nitrogen applications

- Two-way splits are most common, but three-way splits have become popular to allow the correct sulphur application where the product used does not apply the required N dose and/or when using liquid fertilisers with which large doses can be impractical.
- The first dose should not be applied until the onset of spring growth; usually mid-February onwards. Even on backward crops there will be no advantage in treating before this, but delaying much beyond this timing could be detrimental for these, as discussed above. This first dose is likely to contain sulphur as well so the amount of N applied at this timing should not compromise the amount of S.
- The second dose should be applied at the start of stem extension: application of N up to early yellow bud has occasionally increased rape yields in NIAB TAG trials. However, late application can also result in reduced yields and margins in drier seasons where uptake is delayed.
- If this late technique is to be used then good uptake conditions are needed and the total N dose should remain within the stipulated range. This approach is not suitable for backward crops.
- **Additional late season nitrogen** (e.g. liquid N post-flowering) has occasionally increased yield, but only where the total N applied previously was sub-optimal, i.e. a total dose effect rather than a timing effect.
- Data from the AHDB-funded Yield Plateau project (Project Report 502, 2012) also suggested that the plateau was related to declining N doses through the 1990s and early 2000s, even though theoretical yield (from new varieties) was increasing. (Other factors, such as declining P & K use, were also implicated). In the mid-1980s average N dose was above 250 kg/ha N, but for the last thirty years or so it has been below 200 kg/ha.

Using canopy size to determine a crop's total nitrogen requirement

- In practice this need only be considered where the canopy is considered excessively large, and hence adjustments to total N dose may be necessary as described at the start of this section. For normal crops no adjustment is needed and the dose applied should be as outlined above.
- AHDB-funded research showed a strong relationship between measured amount of N in the canopy at the end of the winter and optimum dose of spring applied nitrogen (Figure 11).

Figure 11. N in canopy in January/February and optimum applied N
(from AHDB PR447, excludes Rosemaund 2008)



- However, estimating crop N content from the visual size of the canopy was less accurate than measuring it directly.
- As with winter cereals, **SMN has little or no effect on optimum applied N**, unless exceptionally high. In the above analyses, including measured soil mineral nitrogen (SMN) in the calculations increased the error in estimating the optimum dose of spring-applied N.
- In re-analysing the AHDB project report PR447, NIAB TAG found a simple yet accurate equation for predicting the optimum level of spring N that needed to be applied irrespective of soil mineral nitrogen or yield.

  Spring N required (kg/ha N) = 285 – (2.4 x kg/ha nitrogen in canopy)
- Assessments of canopy N are best taken in February. (Pigeons will reduce canopy size and remove nitrogen in doing so, so assess canopies in early spring (before stem extension) when pigeon damage can be taken into account).

If we assume 50 kg/ha is in the crop's canopy in February then the calculation is as follows:

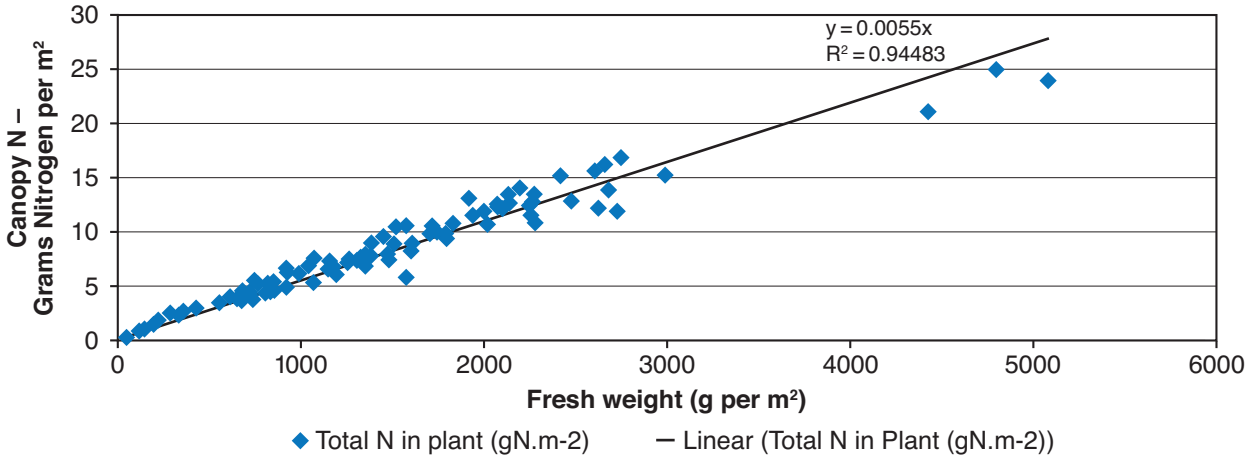
Required spring Nitrogen required kg/ha = 285 – (2.4 X 50 kg/ha)
= 285 – (120)
= 165 kg/ha

Measuring the amount of nitrogen in a canopy

Studies done by NIAB TAG on crops with a wide range of canopies, showed a close relationship between **fresh weight** and **total N** in the canopy.

Therefore every kg per m^2 harvested of fresh above-ground material in February would equate to 55 kg/ha of nitrogen in the canopy itself (Figure 12).

Figure 12. Relationship between canopy size and N content in OSR. NIAB TAG 2012-14
Using fresh weight measurements to determine N in the canopy



Here 1 kg fresh weight/m² relates to the equivalent of 55 kg/ha N in the crop.

Having determined how much nitrogen is in the canopy we can use the equation given or the first graph to determine how much more needs to be applied. However we would suggest it would be prudent to go **no lower than 150 kg/ha of total N for any crop**.

- Managing excessive canopies with nitrogen management should not compromise sulphur treatment. Both forward and backward crops will need **sulphur** and any delays in nitrogen treatment in early spring should not delay sulphur treatment for too long.
- Ongoing NIAB TAG trials on sulphur responses in winter rape are still recording yield losses of around 30% when S is omitted.

b) Growth regulation

Growth regulation is not a routine input for all crops. NIAB TAG's own trials have rarely, if ever, shown any evidence of a yield benefit irrespective of canopy size. However we do not measure 'harvestability' which shorter crops can affect and which can influence harvested yield on a field scale.

Requirement for PGR depends on likely final canopy structure, and whether this will put the crop at risk of lodging or otherwise difficult harvesting. Such crops are typically grown on heavy or fertile soils, are still forward coming out of winter (e.g. above ankle height) and/or have a high plant population (60 plants/m² or more).

Variety characteristics and, of course, past experience are also contributing factors.

If treatment is required, options are:

(i) **Tebuconazole**, e.g. Folicur 0.75-1.0 l/ha
Be aware that label details of tebuconazole products regarding their use in oilseed rape may vary in terms of **total dose** and **number of applications** allowed. Therefore please check the details of products you plan to use, particularly if also using tebuconazole in fungicide programmes.

(ii) **Caramba/Sunorg Pro/Juventus** (metconazole 90 g/l) **0.4-0.8 l/ha**
Max total dose per crop 1.6 l/ha

(iii) **Caryx** (metconazole 30 g/l + 210 g/l mepiquat-chloride) **1.0-1.4 l/ha**
Maximum total dose of Caryx per crop is 1.4 l/ha (only one application per crop, so not an option if applied in autumn), from the beginning of stem extension up to and including yellow bud. (GS31-59). Doses can be altered to reflect the size of the canopy at the start of stem extension.

(iv) **Toprex 0.25-0.35 l/ha** for crops at moderate – high risk of lodging or where crops need significant manipulation for other purposes (harvestability, light penetration in dense canopies).

- Lodging in OSR can significantly reduce yield due to poorer light interception by the canopy just at the time when yield components are being determined. It will also create variable maturity in the crop which itself will lead to yield losses. Lodging can occur as a result of root or stem lodging.
- The stage at which lodging occurs will ultimately determine the effect on yield, the earlier it occurs the more damaging it is likely to be. Therefore growth regulators are most likely to give a cost effective yield response in early emerged, thick, vigorous crops on medium or heavy soils.
- Leaning has also been shown to reduce yield if it occurs early, through reducing the structure and hence efficiency of the canopy during pod fill.
- As well as lodging control, there may be situations where crops grow particularly tall and growth regulation or growth manipulation is beneficial in terms of harvest management.
- Applications should be made to actively growing crops. The degree of growth regulation is variable, and dependant on product timing and subsequent growing conditions. Trials conducted in a dry spring reduced height by only 3-7 cm but in wetter seasons the reduction has been between 10 and 20 cm.
- In other trials, at the Cambridge Centre in 2015, despite reasonably heavy soil the untreated crop only reached a maximum height of 125 cm. Several products were tested (Folicur, Caramba, Caryx) but the maximum height reduction recorded was 5 cm. There were no significant yield differences. In 2016 a trial at Callow (Hereford) recorded a 21 cm reduction in height of a taller crop (1.8 m untreated) from a PGR treatment, though a slight but statistically significant yield reduction resulted.
- Treatment at yellow bud is more effective at canopy manipulation (to aid light penetration and crop structure for harvest) with most products but for the crops most at risk of lodging, greater stem shortening can be seen from earlier treatment, at stem extension – green bud.
- On light soils any forward growth in early spring is less likely to be maintained in the latter part of the season and a benefit from a growth regulator is unlikely. On such soils, in dry springs, growth regulator treatments have reduced yield.
- Growth regulators should not be used on backward, thin crops or crops that are stressed for any other reason.

c) Spring weed control

Grass-weed control

With the application windows for propyzamide, and possibly carbetamide closed, this will rely on the use of **ACC-ase inhibitor** graminicides.

Remember that only two such products can be used in the crop and a particular active ingredient can only be used once. Therefore if one such product has already been used, any second application will need to be a different active ingredient and target different weeds to the first application. If two such products have already been applied, no further selective herbicide control will be legal.

Graminicides: latest authorised timings

Active ingredient	Latest timing (crop)
Propaquizafop (e.g. Falcon)	Before flower buds visible and 90 days before harvest
Cycloxydim (e.g. Laser)	12 weeks before harvest
Fluazifop-P-butyl (e.g. Fusilade Max)	Before flower buds visible, or 2 weeks pre-harvest for industrial use crops
Quizalofop-P-tefuryl (e.g. Panarex)	60 days before harvest
Quizalofop-P-ethyl (e.g. Leopard 5 EC)	15 weeks before harvest

Broad-leaved weed control

Products authorised for use in the spring only control a relatively narrow spectrum of weeds. Favourable weather conditions, both at and after application and help from crop competition are also needed for best results.

Options available are:

- Clopyralid + picloram (e.g. **Galera**) From 1 March to before flower buds extend beyond the uppermost (youngest) leaves. Take note of label comments regarding use of straw and following crops.

  – main weeds controlled – thistles, mayweeds and cleavers.

- Clopyralid (e.g. **Dow Shield 400**, **Vivendi 200**) From 1 March to before flower buds visible (above leaf canopy). Take note of label comments regarding use of straw.

  – main weeds controlled – thistles and mayweeds.

- Bifenox (**Fox**, various others) have EAMUs for crane's bill control (need to treat when weeds are small). It also has activity on pansy, red dead nettle, speedwells, borage, poppy and charlock. Dose to use will depend on the target weed and their size, but for spring use, a three-quarters dose is probably the lowest that is worth applying. The addition of oil may be beneficial if the crop is strong enough. Latest timing is before flower buds are visible, but the additional need for crop leaves to be well waxed, means applications should be made before the start of new spring growth. Bright weather, coupled with frosts following application will enhance weed control.

- **Lentagran WP** (pyridate) also has an EAMU (20093230). It must be used before the start of stem extension on a dry, well waxed crop when temperatures are mild (10˚C +). Cleavers would be the main target weed, very small chickweed may also be controlled.

7. Spring oilseed rape

a) Nitrogen and sulphur

Total nitrogen dose

125 (-150) kg/ha N

- This is suitable for most crops, the precise dose depending on yield potential. This is mainly influenced by variety and how well the crop established, but the short growing season means most crops are unlikely to justify more than 125 kg/ha.
- Low yield potential crops (e.g. drought-affected, or poorly-established), or those grown on fertile land, may not respond to more than 100 kg/ha.

Timing

- Prompt establishment is important to overcome early pest and weed problems. Readily-available nitrogen (i.e. at germination) will help with this, so most of the N should be applied at or very soon after drilling. (Splitting is not necessary but it would be wise to consider holding back some nitrogen in case establishment fails, i.e. restrict 'up-front' expenditure).
- Sowing date should where possible tie in with suitable conditions for prompt emergence and hence immediate N use.
- Where it is more practical to split the total dose apply most to the seedbed and the remainder soon afterwards (ideally within two weeks of the first dose).

Sulphur

- There is little trial data on sulphur response in the spring crop but since almost all other arable crops need sulphur now, it is safe to assume spring rape does also. Dose is likely to be less than for winter rape, but a little more than that for cereals (e.g. 40-60 kg/ha SO_3, approximately 15-25 kg/ha S).

b) Weed control

Herbicides

1. **Pre-emergence** **Metazachlor + clomazone** is an effective mixture used pre-emergence.

   Suggested doses are **0.75-1.5 l/ha metazachlor + 0.15-0.20 l/ha clomazone** (assuming 500 g/litre and 360 g/litre concentrations respectively).

   The crop should be sown in such conditions that it can be used promptly after sowing.

   The lower clomazone dose above is preferable unless weed pressure requires the higher dose since it has been seen occasionally to cause some discoloration of the crop, and to hold it back slightly.

2. **Post-emergence treatment** is much less effective than pre-emergence, but if post-emergence treatment is planned, aim to do so before the crop has five true leaves, as crop shading of target weeds could become a problem after this.

Residual herbicides

- **Metazachlor** (e.g. Butisan S, Sultan) maximum dose 1.5 l/ha can be used pre- or post-crop emergence (up to 10-leaf), but preferably pre-emergence of weeds. Seed must be covered to a depth of 15 mm, and it is not recommended for sands, very light soils or soils with more than 10% organic matter. Note a **permitted** maximum total dose of 1000 g/ha metazachlor over a three year period (but an **advisory** maximum of 750 g/ha for stewardship of the herbicide) can be applied on the same field, which will have implications where winter rape is in the same rotation.
- **Clomazone** (e.g. Centium, Mohawk etc) pre-emergence: see page 46 on possible crop effects. Seed must be covered to a depth of 20 mm, not recommended for sands, very light soils or soils with more than 10% organic matter. Good activity on cleavers, chickweed, shepherd's purse.

Post-emergence, foliar acting herbicides

- Some **clopyralid** products (e.g. Dow Shield 400) can be used to control thistles and mayweeds. Other options are covered by **EAMU** authorisation:
- **Galera** (clopyralid + picloram) has an EAMU authorisation (20140827). This adds cleaver activity and more reliable mayweed and thistle activity at cooler temperatures.
- Bifenox – various products have EAMU authorisation for crane's bill control.
- Lentagran WP also has an EAMU (20093230) for use before stem extension.

The use of bifenox or Lentagran is not really advised unless specific conditions mean they are the only options. Spring oilseed rape crops will rarely be at a safe enough stage to use them.

- **Grass-weed control**: is primarily by use of foliar acting graminicides, although some control/ sensitisation can come from residual herbicides.

Graminicides: latest authorised timings

Active ingredient	Latest timing (crop)	Comments
Propaquizafop (e.g. Falcon)	Before 8 leaf stage	
Cycloxydim (e.g. Laser)	12 weeks before harvest	
Fluazifop-P-butyl (e.g. Fusilade Max)	Before 5 leaf stage	or 2 weeks pre-harvest for industrial use crops
Quizalofop-P-tefuryl (e.g. Panarex (MAPP 17960))	60 days before harvest	
Quizalofop-P-ethyl (e.g. Leopard 5 EC)	11 weeks before harvest	

8. Spring linseed

a) Nitrogen and sulphur

Spring linseed

Total dose – 75-100 kg/ha N is suitable for most crops.

Timing

- 40-50 kg/ha nitrogen should be applied to the seedbed, at or soon after drilling.
- For crops expected to yield well, an additional 30-50 kg/ha can be applied at late stem extension/green bud stage.
- Nitrogen dose should be reduced closer to 40-50 kg/ha N if the site is inherently low yielding, the crop is sown late, e.g. after mid-April, or has the potential for lodging.

Winter linseed

Total dose – 100-150 kg/ha N is suitable for most crops as one or two splits.

Sulphur

Sulphur requirement on medium, light or shallow soils, 25-50 kg/ha SO_3. The higher dose will be required on lighter textured soils and can be applied with the first nitrogen application.

b) Weed control

Broad-leaved weed control

Pre-emergence options

On fields that have a history of large weed populations, using a pre-emergence herbicide is a good idea.

Callisto (mesotrione) has an EAMU for use pre-emergence and is probably the safest for spring linseed. Use at 0.75-1.5 l/ha.

Metazachlor Butisan S and Sultan 50 SC have EAMU authorisations for use either pre- or post-emergence. Consider using at 1.0 l/ha rate if annual meadow-grass or high populations of broad-leaved weeds are expected. See rotational stewardship restriction details later in this section.

Where other grass-weeds are of concern, **Avadex Excel 15G** has an EAMU. This also provides a degree of broad-leaved weed control.

Post–emergence options

1. **Eagle** (amidosulfuron) 20-30 g/ha **± bromoxynil** (e.g. Maya, Butryflow) 1.0 l/ha

   This is first choice as the mix is probably the strongest herbicide choice for linseed and one of the safest to the crop. It has a broad spectrum of broad-leaved weeds that it will control including reasonable activity on cleavers. High populations of, for example, chickweed, speedwells, poppy or mayweed may be more challenging.

   Eagle can be applied in sequence with Jubilee SX (option 3) providing certain conditions on following crops, and condition of the crop to be treated are observed.

   Note that bromoxynil products authorised for use in linseed are SC rather than EC formulations.

2. **Bromoxynil + bentazone** (e.g. Maya 0.5 l/ha + Basagran 1.1 kg/ha)

   A non ALS-inhibitor mix that is a bit stronger (than 1 above) on fat hen, chickweed, mayweed and polygonums.

Other options:

3. **Metsulfuron-methyl**, (e.g. Jubilee SX, Deft Premium) at half or two-thirds dose, will control most broad-leaved weeds in linseed. Under certain conditions even these low rates can cause crop effects. Avoid the higher rates if possible. Fat hen can be a weakness. (There are no tank mix options for these products on this crop, and not all metsulfuron-methyl products are authorised for use in linseed). Products that also contain tribenuron-methyl (e.g. Ally Max SX) have no authorisation and will damage the crop.

4. **Clopyralid** (e.g. Dow Shield 400) can be used either to tank mix to make weed control more robust (specific label details allowing), or to use after other herbicides to tidy up mayweeds, corn marigold and sow thistles. It can be used from 1 March until flower buds visible above the leaves.

5. **Bentazone** (e.g. Basagran SG, see also (2) above) has activity on cleavers, along with some other weeds that may have grown too large for low doses of metsulfuron-methyl or escaped control with Eagle.

   Note **bentazone** has a stewardship code to protect water, the main points of which are:
   - o Avoid using bentazone on soils prone to ground water leaching.
   - o Reduce dose rates to below 1 kg of active per hectare per year.

   Restrictions in place regarding the total dose of **metazachlor** (1,000 g/ha) allowable within a three year period (stewardship scheme recommends a 750 g/ha limit); this amount could be compromised if oilseed rape is already within the rotation. This product is also subject to stewardship guidelines for protection of water.

   Full details available at the Voluntary Initiative website http://www.voluntaryinitiative.org.uk

6. **Bifenox** – some products have EAMUs for linseed. NIAB TAG has no experience of crop safety but it will give useful control at, say, 0.5 l/ha, of some broad-leaved weeds, especially speedwells, pansy and red dead nettle.

Grass-weed control

Other than Avadex as mentioned above, the main graminicide products authorised for use in linseed are translocated ACCase inhibitors:

Propaquizafop (e.g. Falcon)
Fluazifop-P-butyl (e.g. Fusilade Max)
Cycloxydim (Laser)
Quizalofop-P-ethyl (Leopard 5 EC/Pilot Ultra)
Quizalofop-P-tefuryl (Panarex/Rango)

Fusilade Max has an EAMU authorisation in 'linseed', otherwise, note that fluazifop-P-butyl products with a linseed authorisation only have authorisation for industrial use (which will probably cover its use in most, but not all crops).

Centurion Max (clethodim) has an EAMU authorisation but the timing restrictions, along with some question marks about crop safety, mean it is more suited to use in winter linseed than spring linseed.

Linseed is a poor competitor against weeds, and for fields with known high levels of weeds, an alternative crop may need to be considered.

The aim should be to sow when soil conditions are warm enough to get as rapid germination and initial growth as possible and then as far as possible to plan herbicides that have the best crop safety.

Our experience is that good activity on weeds is often coupled with yield penalties and the treatments which will give the cleanest crop may also have the greatest effect on the crop; the best choice will therefore be a compromise, and careful selection of a weed control treatment is needed.

There are a range of EAMU authorisations for some other **residual herbicides** that can be used on linseed. However, most of these are more applicable to winter linseed and as their use is at grower's risk, there is no compensation for crop effects.

Where products are used under an EAMU, use is at the grower's risk and the user must have a copy of the relevant EAMU authorisation document. These are available via the HSE, CRD website: https://secure.pesticides.gov.uk/offlabels/search.asp#help.

9. Spring peas and spring beans

a) Weed control

Herbicides

- Pre-emergence weed control is essential for both crops as these products have the widest and most reliable spectrum of control and are safer to the crop.
- Aim to produce a seed bed which will help get the best from the pre-emergence herbicides.
- However, soil conditions and germination depth of weeds (especially volunteer OSR, cleavers, charlock and runch) will influence the overall effectiveness of pre-emergence sprays. Pre-emergence product choice should aim to provide a broad spectrum of weed control. It should also take into consideration their relative strength on expected problem weed species based on previous field experience. It is important to get this right as post-emergence choices have a narrower weed spectrum, are less reliable and can cause some crop damage.
- Spending less on pre-emergence weed control can be a false economy except where it is anticipated that some post-emergence control is also likely to be needed and has worked on your weed spectrum in the past.
- If weed control in the crop is compromised, pre-harvest desiccation with glyphosate or diquat is an option for combining peas and field beans. Final use date for diquat products is 4 February 2020, so this is the final season of use.

Pre-emergence herbicide options

Active ingredients	Example products	Strengths	Other comments
clomazone	Centium 360 CS	Cleavers, chickweed, fools parsley	Some of the only pre-emergence products other than Nirvana that have a full label authorisation for spring beans
pendimethalin	Stomp Aqua, Anthem and others	Useful weed spectrum, but weak on mayweed	Combining peas only. Many products also have **EAMU**s for spring beans and vining peas
prosulfocarb	Defy	Useful weed spectrum, including cleavers, crane's bill and mayweeds	**EAMU** in spring beans only
clomazone + pendimethalin	Stallion Sync Tec	Non EAMU pendimethalin for spring beans and vining peas	Authorisation in vining peas is as a 'qualified minor use' as crop safety has not been fully assessed
imazamox + pendimethalin	Nirvana	Good weed spectrum, including vol. OSR and charlock	More expensive than some other options
S-metolachlor	Dual Gold	Mayweed activity, but not good on polygonums or cleavers	**EAMU** in spring beans and vining peas; use from 1 March to 31 May only

Post-emergence broad-leaved weed herbicides

Active ingredients	Example products	Strengths	Other comments
bentazone	Basagran SG and others	Useful weed spectrum	Only certain varieties of spring beans and peas can be treated. Care needed with application to get best weed control and avoid crop damage
MCPB	Tropotox, Butoxone, Bellmac Straight	Can be alone or in mixture with bentazone	Not spring beans. Check variety lists for peas
flumioxazin	Sumimax, Digital, Guillotine	Suppression of vol. potatoes	EAMU in **vining peas only**

Post-emergence broad-leaved weed herbicides

Active ingredients	Example products	Strengths	Other comments
cycloxydim	Laser	Good on rye-grass, bromes and wild-oats	Requires addition of adjuvant oil. Couch control at high rates
fluazifop-p-butyl	Fusilade Max	Broad spectrum	
propaquizafop	Falcon	Broad spectrum	Not in vining peas
quizalofop-p-ethyl	Leopard 5 EC	Broad spectrum	Couch control at high rates
quizalofop-p-tefuryl	Panarex	Broad spectrum	Not in vining peas
clethodim	Centurion Max	Black-grass	EAMU in **vining peas only**

All the post-emergence grass-weed herbicides listed above are ACCase inhibitors.

For all post-emergence products, adequate leaf wax needs to be present to prevent crop damage. If more than one post-emergence product needs to be used, adequate time intervals between applications also need to be observed to prevent crop damage. These requirements can easily become a limiting factor in post-emergence weed control.

- Note bentazone has a stewardship code to protect water, the main points of which are:
  - Avoid using bentazone on soils prone to ground water leaching
  - Reduce dose rates to below 1 kg of active per hectare per year

  Full details available at http://www.voluntaryinitiative.org.uk

Where products are used under an EAMU, use is at the growers risk and the user must have a copy of the relevant EAMU authorisation document. These are available via the HSE, CRD website: https://secure.pesticides.gov.uk/offlabels/search.asp#help

Cultural control

- Ploughing and/or glyphosate will help kill any germinated weeds before sowing.
- For peas, the crop's own competitiveness will be enhanced by uniform seed spacing and depth of drilling in ensuring a rapid and evenly-emerged crop to maximise ground cover.
- Inter-row harrowing at early crop emergence is an option in spring beans.

10. Seed rates and target populations for spring crops

Below are target plant populations for spring crops in 2019.

We have tried to indicate typical thousand-seed-weights (TSW) to help with seed orders, but we would stress that this can vary considerably and if possible you should get an accurate figure from the seed merchant.

Although it is difficult once a quantity of seed has been purchased, it is important to be flexible and be prepared to increase the seed rate if sowing is delayed.

In all cases the higher seed rates are appropriate for less favourable conditions, e.g. late or very early drilling, excessively wet or dry seedbeds etc.

Crop	Target plants/m²	Typical seeds/m²	Comments
Spring barley	250-300	300-350	
Spring wheat	250-300	300-350	
Spring oats	200-300	325-400	
Peas	65-90		See formula below
Spring beans	40-55	45-60	Rate depends on site fertility
Spring OSR	75-100	120-140	High seed rates allow for flea beetle losses
Linseed	400-800	700-900	High seed rates allow for flea beetle losses

For all crops, **TSW (g) x seeds/m² x 0.01 = seed rate in kg/ha**

e.g. TSW 44 g, 350 seeds/m² chosen rate, so 44 x 3.5 = 154 kg/ha
TSW 44 g, 400 seeds/m², so 44 x 4 = 176 kg/ha
TSW 50 g, 400 seeds/m², so 50 x 4.0 = 200 kg/ha

Direct drilling

Where sowing any spring crop without soil movement the resulting crop will always be thinner, often due to less than ideal seedbed conditions. There are two remedies: firstly, wait for better drilling conditions or, secondly, increase the seed rate. Experience of these scenarios would suggest that you need to increase the seed rate of a spring crop going into a cultivated, well-made seedbed by 20% in order to achieve the same population in no-till. Previous experience of this scenario will give better guidance, but in order to achieve an acceptable plant stand this will normally be necessary.

Peas: Small blues require around 90 plants/m², while larger seeded varieties and marrowfats will be in the 65-70 range. Typical TSW 240-300 g (whites and large blues), 350-400 g (marrowfats).

The PGRO formula will give required seed rates:

$$\text{Seed rate in kg/ha} = \frac{\text{TGW x target population (plants/m}^2\text{) x 100}}{\text{\% germination} \qquad \text{100 - field loss}}$$

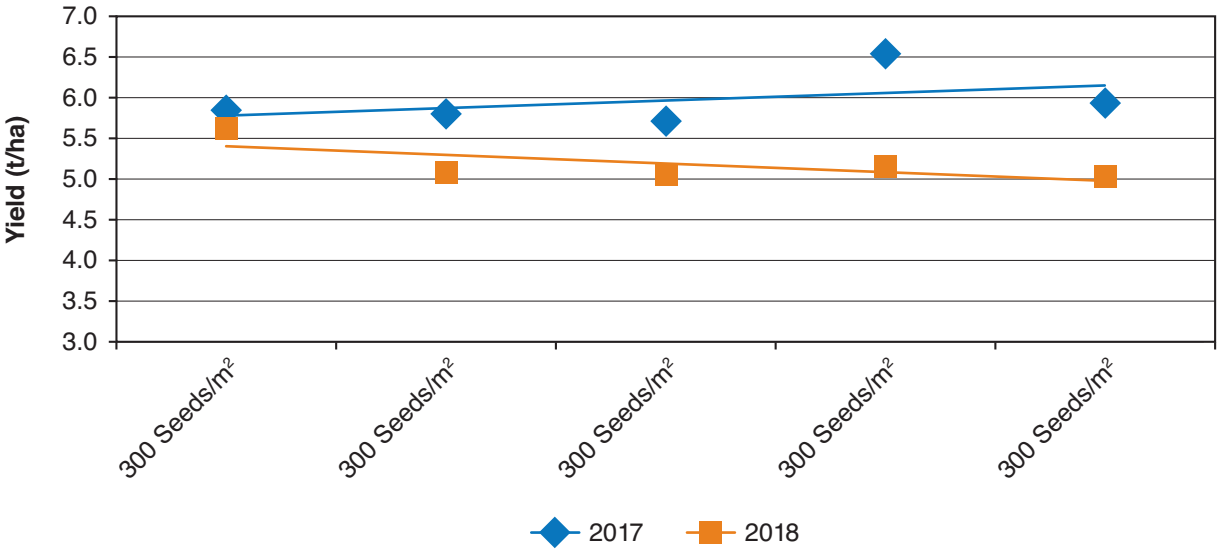
Field loss: February: marrowfats 15% others 18%. March: marrowfats 10% others 13%, April: marrowfats 5% others 7%.

Ongoing trials by PGRO re-examine these guidelines and while they still appear to hold for marrowfats, for other types (e.g. large blue) higher populations than suggested here may give better returns. This work continues (www.pgro.org – see Pulse e-book winter 2018) but for the time being it may be worth aiming for plant populations at the higher end of the ranges listed.

Spring barley seed rates

Two years of work on spring barley seed rates at Cirencester have shown a fairly flat response, despite late sowing (31 March in 2017 and 20 April in 2018) on a light drought-prone soil (Figure 13).

Figure 13. Spring barley seed rates and yield, Cirencester 2017 and 2018



More details of these trials can be found in the Members Trial Results booklets.

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